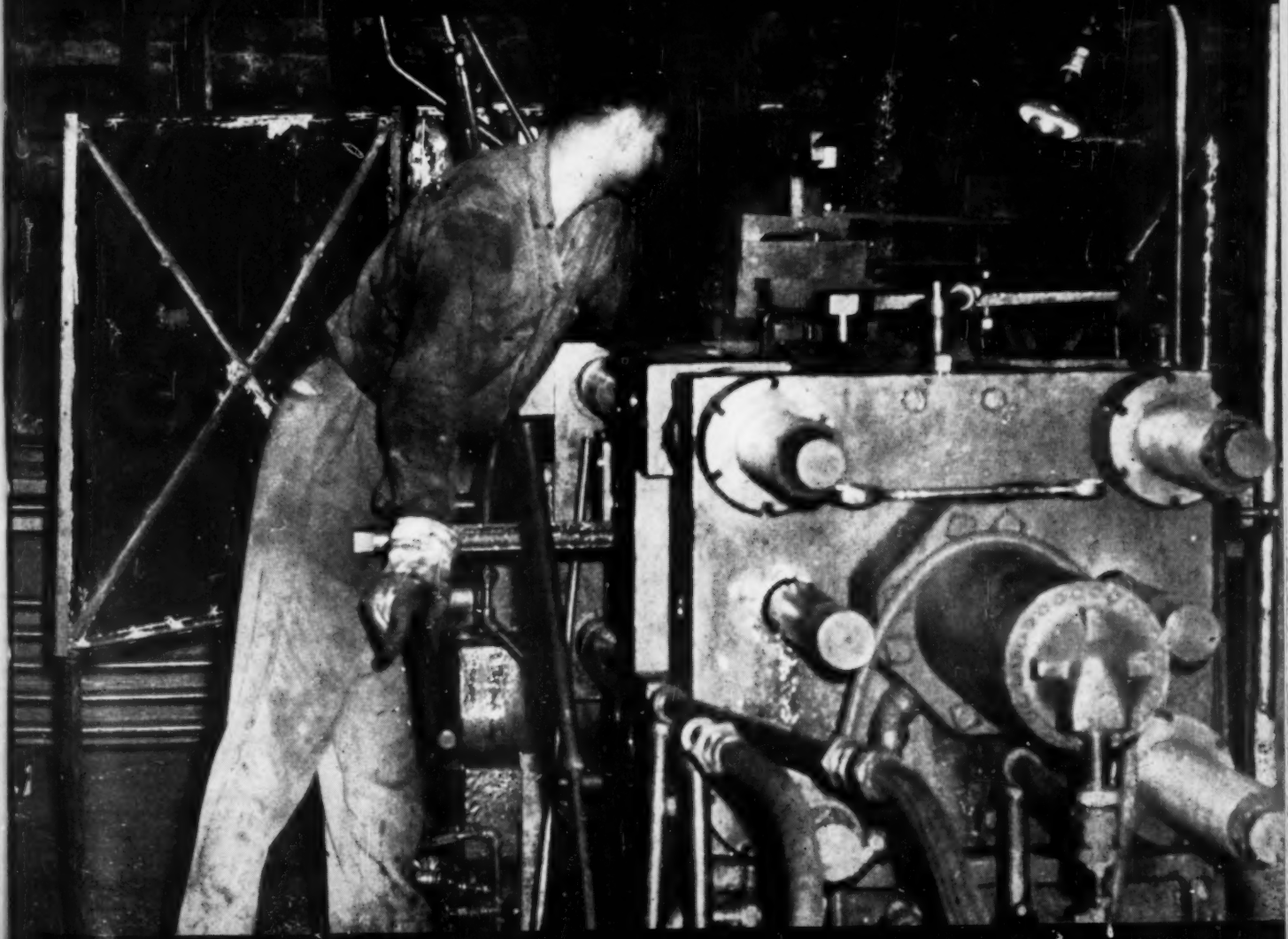
Applied HYDRAULICS



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LINDBERG AIR CYLINDERS

SEPTEMBER, 1948

Vol. 1 No. 8

Applied HYDRAULICS

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FRONT COVER: A hydraulically actuated diecasting machine, designed and built by the Mount Vernon Die Casting Corp., in operation in their Mount Vernon, N. Y. plant.

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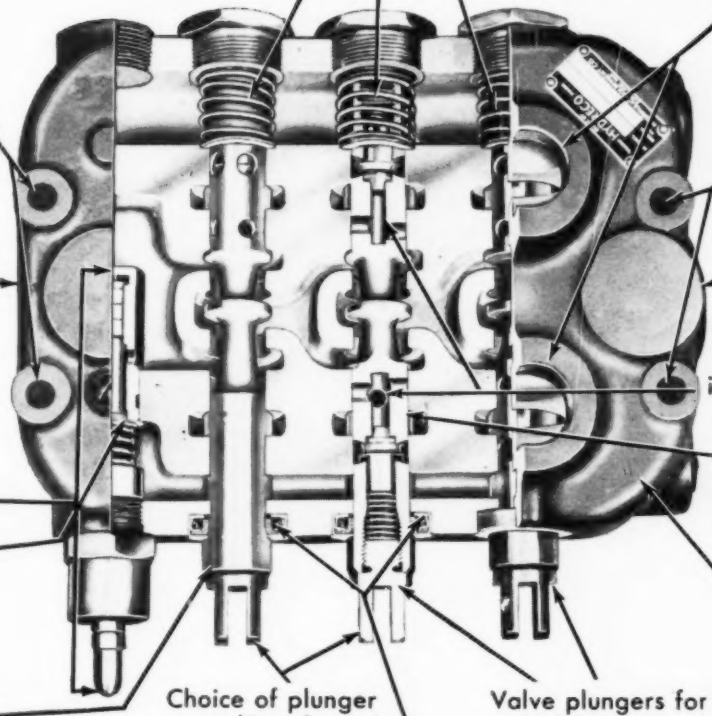
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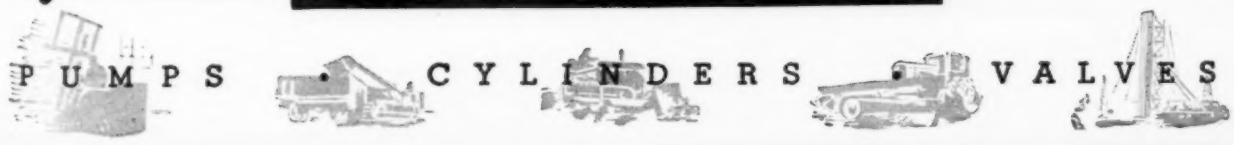


PUMPS • CYLINDERS • VALVES

HYDRAULIC EQUIPMENT COMPANY 1104 EAST 222nd STREET • CLEVELAND 17, OHIO

By RICHARD C. ROETGER

ELECTRONICS NEED NOT SCARE YOU

An introduction to the subject of vacuum tube control circuits and their nomenclature. Fundamental units and their uses are surveyed, the variable control characteristics of various tubes are given and a complete electronic system is analyzed in terms of the functions of its component units.

Richard C. Roetger is an electro-mechanical designer and development engineer and a consultant in the electronics field. His extensive industrial experience has been with such leading organizations as Babcock and Wilcox Company, Union Carbide and Carbon Corporation, W. L. Maxson Corporation and Whipple and Rattray. He was associated with the latter company for fifteen years.

Mr. Roetger is a graduate of Stevens Institute of Technology. He has contributed numerous articles to the business and technical press. He is the author of "Industrial Electronics Maintenance", published last year.

"ELECTRONICS" is a much abused word. Newspapers, advertisers and psuedo-scientific publications have played with it to the extent that to many people it is synonymous with radar, analog computers, guided missiles and electric blankets. This has had two unfortunate results, even among engineers well trained in other fields but not familiar with electronics. First, that electronic equipment is very complex, expensive and highly critical in all respects and, second, and directly opposite, that electronics is a panacea for all hydraulics and mechanical difficulties.

The first group should realize that there are many simple electronic devices such as timers, regulators and relays that are hardly more complicated than a domestic oil burner system and that they often will simplify and reduce the cost of a control problem. The others must understand that electronic apparatus is not always an "over the counter" proposition, for in many cases it must be custom made for the applications and in other instances there are other better ways of doing the job.

Definition of Electronic

Scientifically, electronics may be defined as the study of electron behavior in a gas or vacuum; therefore in a gas filled or evacuated envelope or tube. Electronic equipment then, is that including such tubes.

It is difficult to segregate electronic equipment as to purposes or types because a line of demarcation does not always exist between them. The following breakdown is intended as a basis for description and although there are specific exceptions and overlapping they are often overlooked in the interest of clarity.

Relays

Electronic relays serve the same purpose as the older electro-magnetic type and are more flexible, may be made more sensitive and are adaptable to a greater variety of initiating impulses. Electro-magnetic relays depend upon a small voltage to control a large voltage or current. Electronic relays may also use a small controlling voltage (and this may be much lower than required by the magnetic type) or they may be actuated by a beam of light, a change in a magnetic circuit or a change in electrical capacity between circuit elements.

By incorporating a resistance-capacity circuit the electronic relay may be designed for delayed pick-up or delayed drop-out with greater flexibility than is possible with dashpot, thermal, or mechanical delay arrangements.

Timers

Timing and sequencing of operations such as required in a spot welding machine are accomplished by a combination of electronic time delay relays. In a three-step operation there would be three relays, each set for the delay time required for the step it is controlling. Completion of the first step would

initiate the second step and when the second step ended the third would automatically start. In some instances the cycling would be continuous, i.e., the first step would be restarted by the end of the third. Other cases might require a separate influence to restart a complete cycle.

Sometimes a timer can even be made to select the correct time for an operation. Such a device is represented by an electronic photographic exposure control for making enlargements and similar purposes. The amount of light transmitted by the negative is measured by a phototube (electric eye) and the "answer" obtained by the phototube is used to vary the delay time of an electronic relay arranged to cut off the light after the delay interval.

There are, of course, other types of timers. However, those based on the resistance-capacity circuit are probably the most likely to be encountered in the simpler control equipment.

Generators

High frequency currents used for induction heating of metals and particularly for the dielectric heating of non-metals may be generated electronically. High frequency currents so produced may also be used for control purposes when it is necessary to transmit the impulses over the same wires used for power, or without wires, i.e., by radio.

Variable Controls

This caption was selected, after considerable thought, to embrace that electronic equipment in which a gradual variation of the input (controlling influence) produces a similar gradual variation of the output. Note that this type of response is distinctly different from the "on-off" action of a relay.

This type of control has been put to a great many uses; among the more common are the stepless control of fractional and integral horsepower motor speed, automatic machinery, fluid flow and temperature. The control in each case may be manual, e.g., a small potentiometer, or an automatic means such as a phototube, a pressure actuated diaphram or a float.

Electron Tubes

If an engineer is to be conversant with the application of the equipment outlined, he must understand something of the circuits involved and the reasons for variations. Obviously, a knowledge of electron tubes and what they do is indicated. The following is presented with the thought that the absence of theory and "math" will encourage the non-electrical engineers to read it.

Electronic tubes may be classified in a number of ways; perhaps the easiest to grasp is the high vacuum-gaseous distinction. As the terminology implies, vacuum tubes are exhausted to a high degree and are sometimes referred to as "hard" tubes. Gaseous tubes, frequently called "soft" tubes, contain small quantities of inert gas. Technically, there is a third type, the mercury vapor containing tube: its action is similar in many respects to the gaseous tube.

The European nomenclature is unquestionably more informative than ours since they call a tube a valve. A tube is definitely a valve for the control of electric current flow. (The mention of "current flow" may be criticised by contemporary students; however, it seems preferable here where it cannot be assumed that the reader has any knowledge of electron theory.)

A two element tube, known as a diode, contains a cathode or filament and an anode or plate. When the anode is positive with respect to the cathode current flows through it. If direct current is applied flow is continuous; if alternating current is supplied, flow occurs on the positive half cycles only.

A three element tube has in addition to the cathode and anode a third element called a grid. Such a tube is called a triode. When a second grid is added the tube becomes a tetrode; when a third grid is added the tube is a pentode, etc. (A twin tube is one which contains two complete sets of elements in one envelope, e.g., two diodes or two triodes.)

The purpose of a grid (con-

This article is the first of a series designed to give the reader without benefit of formal electrical training, an orientation knowledge of electron tubes, what they do, how they do it and why they are important in control circuits. The emphasis is on industrial control applications; fundamental principles are covered first, specific applications later.

Theory is avoided as also are references to scientific, communications and highly specialized electronic equipment. A familiarity with common electrical components such as relays, transformers, resistors, motors, generators and capacitors and some conception of the difference between alternating and direct current are the only assumptions made.

sidering a triode for simplicity) is to control the magnitude of the current in the anode circuit. In a vacuum triode, anode current varies continuously with the voltage applied to the grid but the change in current is great for a small change in grid voltage. By making the grid sufficiently negative anode current may be cut off entirely.

In a gas triode conduction of anode current will not take place if the grid is sufficiently negative; however, once conduction is started by making the grid more positive, the grid loses control and conduction continues as long as the anode voltage remains above a critical value. When alternating current is applied to the anode the grid regains control during each negative half cycle. By controlling the point during the positive half cycle at which the grid "fires" the tube, considerable control of the output is obtainable.

It must be remembered that each class of tubes comprises different types which are enumerated below as to usage. Of course, there are exceptions, just as an incandescent lamp might be used as a source of heat or a relay might be connected as a buzzer.

Rectifiers

A down-to-earth definition of a rectifier is: something that changes alternating current to direct current. There are electron tubes that do just that; and electronic engineers have names for each particular kind.

Broadly speaking, rectifiers may be divided into two classes: (1) uncontrolled; and (2) controlled. Uncontrolled rectifiers are analagous to simple flapper type check valves; they will conduct the positive half cycles of the alternating current in an amount up to the limit of their design capacity. Controlled rectifiers conduct all or *a part of* the positive halfcycles of the alternating current depending upon the electrical conditions imposed on the controlling element, the grid. Thus, the output may be controlled in a quantative sense.

The principal classes of rectifiers are:

Kenotrons are uncontrolled vacuum type rectifiers designed for high voltage, low current service.

Phanotrons are uncontrolled gaseous tubes intended for medium voltage, medium current applications.

Thyratrons are controlled gaseous rectifiers most generally found in medium voltage, medium current uses.

Ignitrons are controlled rectifiers designed for low voltages and high currents.

Uncontrolled rectifiers are used when a steady source of direct current is required, replacing rotating machinery for this purpose.

Controlled rectifiers, thyratrons in particular, are used to provide direct current machinery with a variable source of direct current converted from the alternating current supply line without use of rotating machinery such as motor-generator-exciter units.

Amplifiers

Vacuum tubes containing an anode, cathode and one or more grids are known as *Pliotrons.*

Pliotrons are used extensively as amplifiers because small changes in grid voltage produce large changes in anode current and because the grid maintains control throughout the range of plate current for which the tube was designed. This statement applies to both alternating and direct current. Thus, they may be considered flow control valves with a pilot.

If the amplification or gain from one tube or stage is insufficent for the purpose at hand its output is applied to the grid of a second pliotron. This forms a two stage amplifier in which the total gain equals the gain of the first tube multiplied by the gain of the second tube.

Amplifiers are needed in any control circuit where the output of the controlling influence is not sufficient to do the mechanical or electro-magnetic work required. A phototube, for example, cannot control enough current to operate a small relay but it will handle sufficient current to influence the grid of a pliotron whose characteristics are suited to the relay.

Another purpose of amplifiers is to improve the sensitivity of a system. Imagine, for example, a control circuit consisting of a liquid level float arranged to rotate a potentiometer which, in turn, governs the speed of a variable capacity pump. Now assume that a drop in level producing a ten degree rotation of the potentiometer results in a ten percent change in pump speed. If an amplifier having a gain of five to one is included in the system the necessary potentiometer rotation required for the same change in pump speed is only two degrees.

Relay Tubes

Pliotrons and thyratrons both function as relay tubes. Actually in this use they perform as single stage amplifiers but they are separated here to indicate their use as "on-off" devices.

A phototube, for example, will "swing" the grid of either a small pliotron or thyratron but the thyratron will handle more anode current. If closing of a magnetic relay is the object, nothing is gained from the gradual plate current change which may occur in the pliotron and the thyratron may be more suitable.

Phototubes

Phototubes contain a light sensitive cathode and an anode and conduct only when the anode is positive. They do not generate electricity as do photovoltaic cells such as used in photographic exposure meters but, like pliotrons, act as flow control valves. While the anode current in a pliotron is controlled by the grid, the anode current in a phototube is governed by the light striking the cathode—no light, no current; maximum light, maximum current.

Both gaseous and vacuum phototubes are available; the

(Continued on page 14)

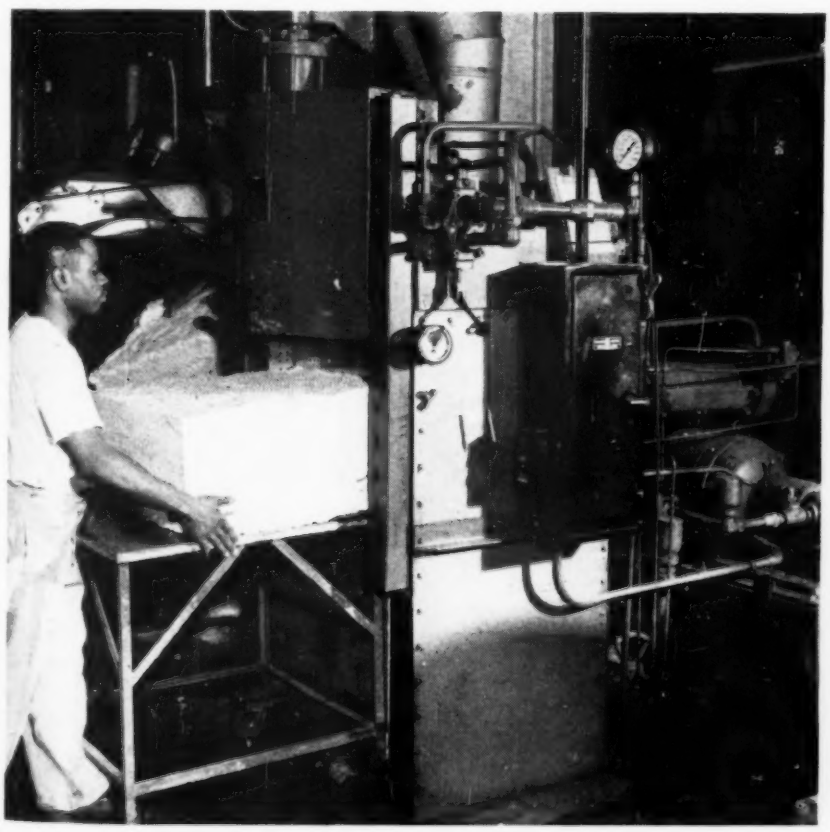
INCREASING LAUNDRY PROFITS

A compression type extractor, operated hydraulically, offers important advantages to the industrial laundry—increased capacity, faster loading and unloading, decreased operating and labor costs.

THE HYDRAULIC extractor is a new type of laundry equipment that extracts by compression instead of by centrifugal action. It resembles a baling machine in some respects and was developed originally for the industrial laundry.

Eighteen months ago the Independent Towel Supply Company of Cleveland installed the first of their four hydraulic extractors. Like other linen supply plants and industrial laundries, their problem of getting more work out each day is a critical one. When this is possible using the same or less space, with equipment that fits in to good advantage with their existing layout, and when a labor saving can be added at the same time, the combination means dollars and cents. On the basis of the increased daily capacity possible with the hydraulic extractor, the Independent Company placed an order for their first machine.

Fig. 1. At the end of the cycle the push-out cylinder ejects the cake or bundle onto an unloading tray.



The daily output handled by the machine reached an average output equal to that of three standard centrifugal machines. On the basis of 200 pounds of dry weight of material per load, the hydraulic extractor handled approximately 12 loads per hour or well over a ton, dry weight, per hour.

This increase in production permitted the centrifugal extractors to be used for materials with metallic parts, buttons or attachments that might be damaged in a high pressure operation.

Centrifugal extractors must be "balance" loaded, requiring a relatively slow hand operation. There is no balancing problem with the hydraulic extractor. Work is loaded in baskets "as it comes". After compression the work is unloaded without any pulling whatsoever, in the form of a compact cake. The small size of this cake (26 x 28 x 14 to 16 in) as ejected from the machine makes it literally a "pushover" at the tumblers. The cake can be fed into the tumblers in less than 10 seconds. In contrast, an equivalent load would require from one to two minutes to load a tumbler with centrifugally extracted materials.

The electric service demand charge is reduced with the hydraulic extractor because the unit pumps oil at a constant rate during the compression part of

the cycle. For this reason, the peak load never exceeds the horsepower rating of the pump motor. By contrast, centrifugal extractors require high torque type motors capable of horsepower equal to 3½ to 4½ times their normal running horsepower rating.

The hydraulic extractor speeds washroom production by eliminating waiting time caused by the "open" wheels. By eliminating this idle time, the hydraulic extractor cuts the overhead charges that run on during waits — cutting the cost per pound of processing.

In this highly competitive business, equipment must operate month after month and year after year without prolonged shutdowns. Like many comparable companies in the laundry field, the Independent Towel Supply Company maintains a skilled maintenance department. In eighteen months it was necessary on only one or two occasions to call in outside help for service.

Finally, the hydraulic extractor has been a labor saver. Special caster equipped special metal baskets are loaded directly from the washer and wheeled directly to the extractor. The operator pushes the basket into place, sets a timer and moves his operating valve.

After extraction is completed, the operator again moves the lever of the operating valve. The front door opens and the push-out cylinder ejects the tightly packed cake or bundle. This constitutes the entire handling between the washers and the tumblers.

The profitable operation of the first hydraulic extractor in this plant led to the installation of a second, then a third, and finally, to a fourth extractor.

The Cleveland Towel Supply Company, also of Cleveland, is a smaller plant doing the same type of work. Their power equipment is all on one floor, making the layout of equipment for an efficient flow of work very important. The hydraulic extractor was easily installed in the centrifugal extractor line with space to spare for extra baskets.

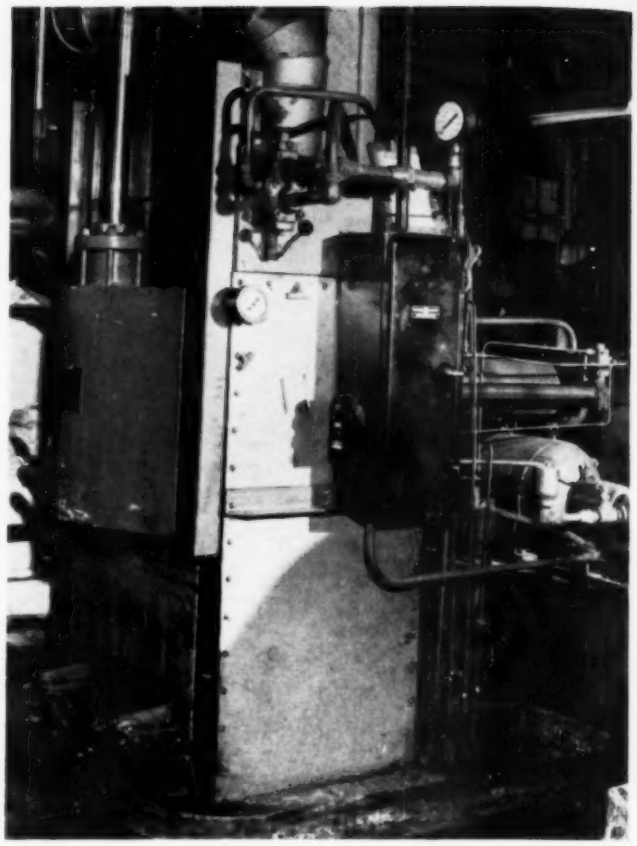


Fig. 2. The hydraulic extractor at the beginning of its cycle with a basket load in position in the extraction chamber.

The capacity of the hydraulic extractor in this plant is figured in loads per day of operation. The company estimates that an average of 96 loads per 8-hour day is handled by the extractor. In this plant the hydraulic extractor does the work formerly done by four various size centrifugal extractors. The centrifugal extractors have been retained in service to do several classes of work not adaptable to the hydraulic equipment. The centrifugal extractors also serve as standby equipment. However, the hydraulic equipment has had only four or five days of downtime in over a year of operation.

The extractor is a fully hydraulic machine. The main job of extraction is done by a large vertical ram, mounted in a pit below the floor level. A second smaller ram, mounted horizontally on the rear of the machine, acts as a push-out or ejector, to push the bundle out of the extraction chamber at the end of the cycle. A third cylinder, mounted vertically, opens and closes the front door of the extraction chamber. The machine is installed with the large ram platen, which covers the head of the vertical ram, flush with the floor.

The false bottom of the basket lifts free as the vertical ram ascends. Drainage is provided on all sides and bottom of the extraction chamber to allow the water extracted to flow to the sewer below the floor level. A high percentage of water by weight is contained in the basket loads as they are received from the washers. In the compression process the total water content is reduced to an estimated 50 percent of the dry weight.

The ascending ram applies a steadily increasing pressure until the full pressure of 2500 psi is reached in 1½ to 2 minutes. When the operating time cycle has been reached, the operator releases the pressure by opening the operating valve. The door opens, the push-out cylinder moves forward, ejecting the bundle from the extraction chamber onto the unloading tray. The main press ram sinks to its fully retracted position

and the push-out cylinder retracts, completing the cycle.

The advantages of the hydraulic extractor are being enjoyed by laundries in all parts of the country. Well over 100 installations have been made in the last 21 months. These advantages are: (1) an increase in work-handling capacity; (2) savings on loading and unloading time; (3) savings in tumbler loading time; (4) decreased prime mover investment and operating costs; (5) a "balancing" and speeding up of washroom production; and (6) a decrease in overall labor costs.

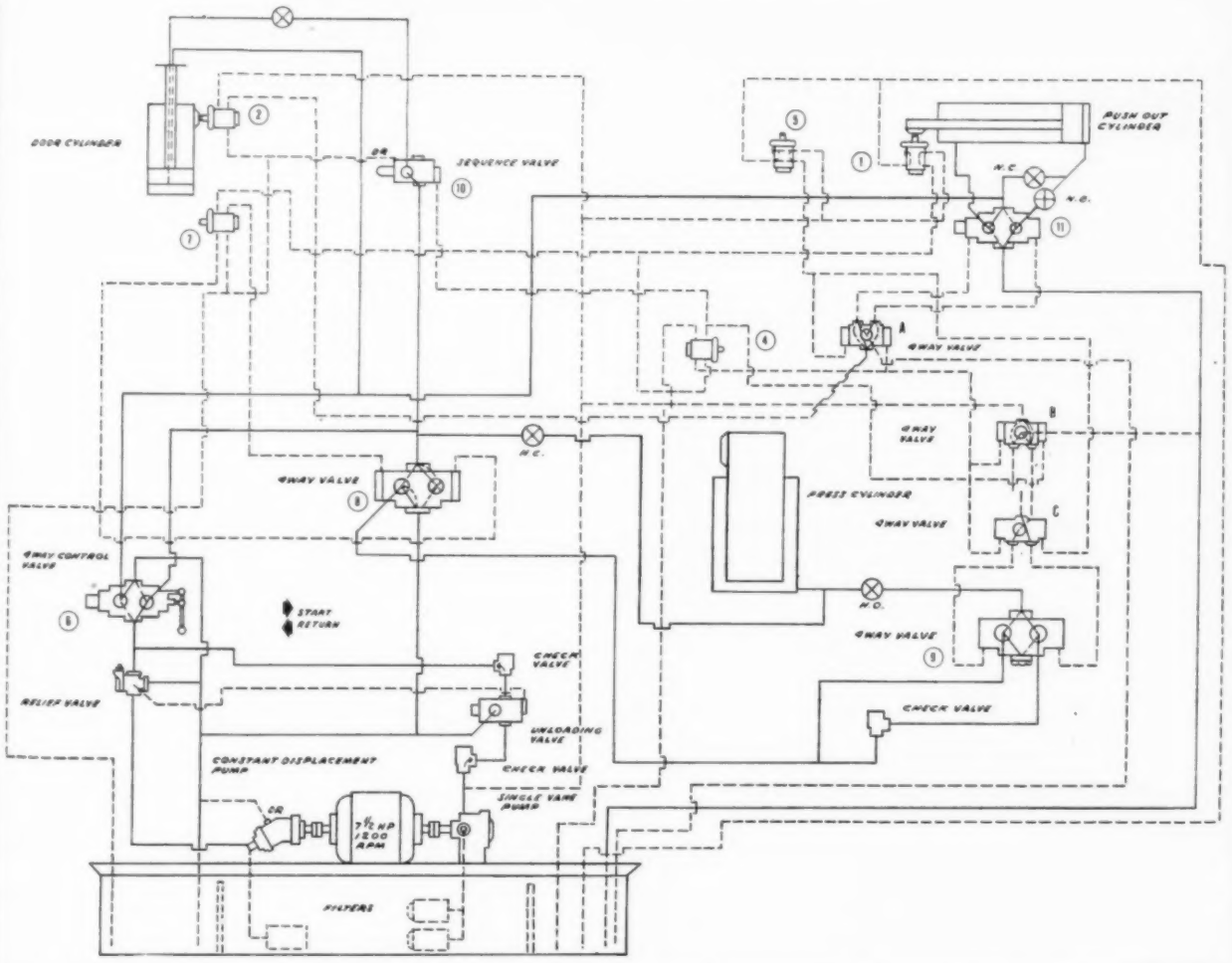
Fig. 3. Circuit diagram and how it works.

The operators initiates the cycle by manually shifting 4-way control valve (6) to the start position. This directs delivery of both pumps to the head end of the door cylinder, causing it to close. When the door is completely closed, pilot pressure is directed through cam operated pilot valve (7) to 4-way valve (8). Pressure shifts the spool of valve (8), directing delivery of both pumps to the press cylinder, causing it to close rapidly. As the work resistance increases, the large volume, low pressure pump is unloaded to the tank; while the pressing stroke continues at a slow rate determined by the delivery of the high pressure, low volume pump. Pressing continues until the pressure setting of the relief valve is attained.

The pump initiates this pressure until the operator shifts the 4-way valve (6), which action controls the release of pressure from the ram. When the pressure gage shows a low reading the valve is moved the remainder of its travel to initiate the unloading operation. The ram begins to descend, discharging oil to the tank until the stem of pilot valve (4) rides off the cam. This simultaneously shifts 4-way valve (B) and opens sequence valve (10). Shifting of valve (B) in turn shifts valve (9) which directs the outlet from the ram against the check valve, preventing further lowering of the ram and stopping the ram at the unloading level.

As valve (6) was shifted pressure was directed to open the door. However, this action was delayed until valve (10) was opened to provide a return from the door cylinder. Opening the door depresses the stem of pilot valve (2). This directs pilot pressure through valve (A) and valve (C). The shifting of valve (A) shifts valve (11) to return the push-out cylinder to its starting position. The shifting of valve (C) will shift valve (9), permitting the ram to descend to the loading position.

With all cylinders returned to their starting positions, the operator centers the control valve to unload both pumps.



AIR CIRCUITS FOR CONVEYOR OPERATION

By W. J. SCHUPNER
Design Engineer
Chicago, Ill.

"HANDLING things from where they are to where you want them" very often is work that is best done by a conveyor. Nearly every modern plant has material handling equipment of some sort and air circuits play no small part as major components in the efficiency of the system.

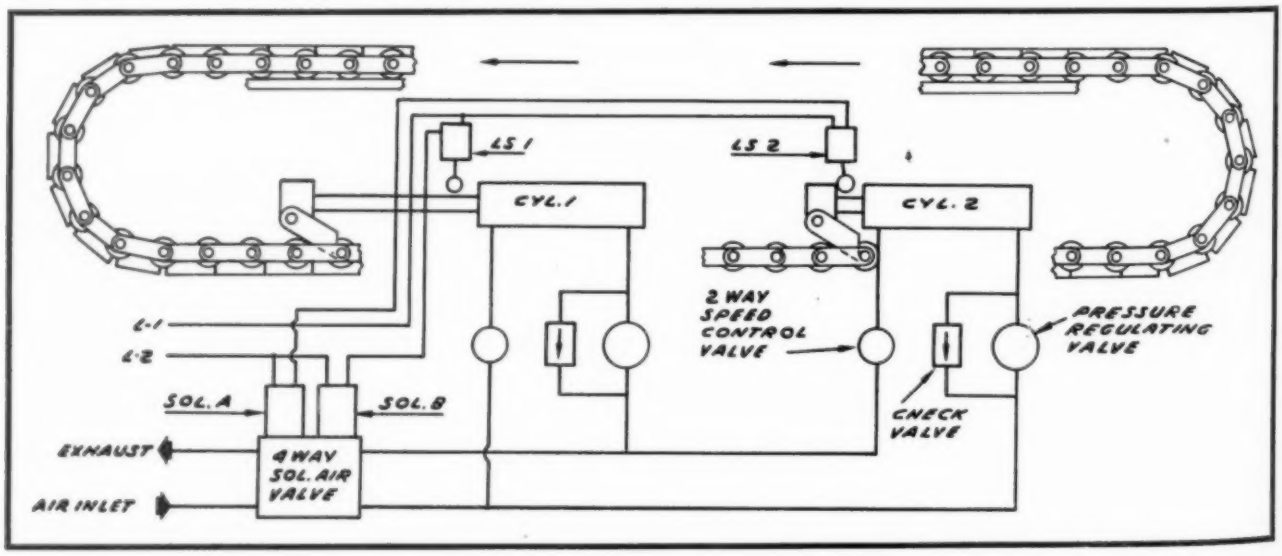
The three sketches shown here indicate briefly a manner in which air cylinders may be applied to conveyors to do work which in many cases would require a great deal of mechanical equipment if done otherwise. One important feature of using air for this purpose is that speeds and pressures may be easily varied by the use of proper valving—an important factor in meeting changing work conditions.

Opposed Cylinders Give Continuous Motion

Figure 1 shows a chain type conveyor which is actuated entirely by air — two cylinders working simultaneously result in practically continuous motion. It operates in the following manner:

Air from the 4-way double solenoid valve is directed to the rear of the cylinder number 1 and the front of cylinder number 2. Reversing the valve admits air to the front of cylinder number 1 and the rear of cylinder number 2. A crosshead is attached to the ends of the piston rods supporting two pawls which engage the trolley wheel axles between the chains. The crossheads further serve to close the limit switches which operate the valve. When the electric circuit is closed, LS-2 will energize solenoid "A" causing piston in cylinder number 2 to move forward and piston number 1 to move backward pulling the conveyor chain with it. Then LS-1

Fig. 1.
TWO AIR CYLINDERS ACTUATE CHAIN TYPE CONVEYOR



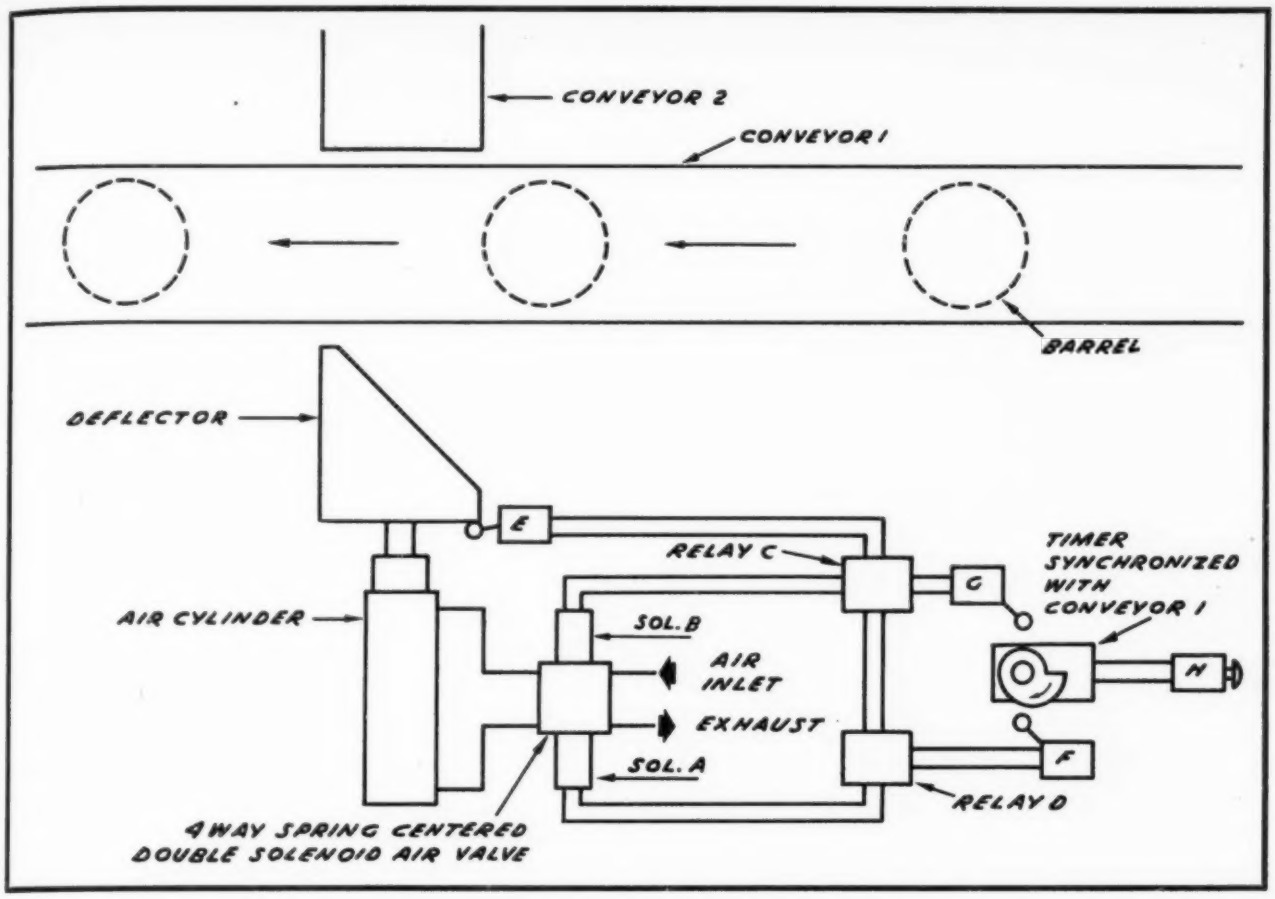


Fig. 2.
AIR CYLINDER OPERATION SYNCHRONIZED WITH CONVEYOR

energizes solenoid "B" and piston number 2 pulls the chain backward — piston number 1 moving forward. Since the forward movement of the piston is idle, low pressure only is required — hence the pressure regulating valve which saves air, since a smaller volume is consumed, at lower pressure. The by-pass check allows free passage of air from cylinder to exhaust. Speed control valves determine conveyor speed.

On a production chain, one cylinder alone may be used with a timing device to move the conveyor a short distance at stated intervals.

Cylinder Operated Deflector to Load Cross Conveyors

In Figure 2 a slat or flat top conveyor (1) is shown moving barrels. The purpose of the air cylinder here is to push or deflect a pre-selected barrel onto a conveyor (2) which is at right angles to the first conveyor, and return the deflector immediately without touching the following barrel. The operator stands at a control station along side of conveyor number 1 which may be some distance from conveyor number 2. As the selected barrel passes a given point in front of him he presses pushbutton "H". This starts an electric timer which is synchronized to match the speed of the conveyor. Just as the barrel reaches conveyor number 2 a cam on the timer closes limit switch "F" which in turn closes relay "D"— energizing solenoid "A" on the four-way valve and directing the deflector forward. After barrel has been transferred to conveyor number 2, cam on timer closes limit switch "G" to operate relay "C" which breaks holding circuit in relay "D" and at same time energizes solenoid "B" causing piston to return. Deflector on returning opens limit switch "E" breaking holding circuit in relay "C" which returns valve to center position.

Relays are used in this circuit because the 4-way operating valve is of the spring-centered type with both cylinder ports open to exhaust in the neutral position, enabling the piston to operate at high speed since there is no trapped air ahead of it to be pushed out. The forward piston speed in this setup is six-tenths of a second with a dwell of one and two-tenths seconds at the end of the stroke before returning.

There may be several cross conveyors similar to conveyor number 2 with duplicate air circuits to serve them; all working independently of each other.

Cylinder Operated Bumper and Transfer Conveyor

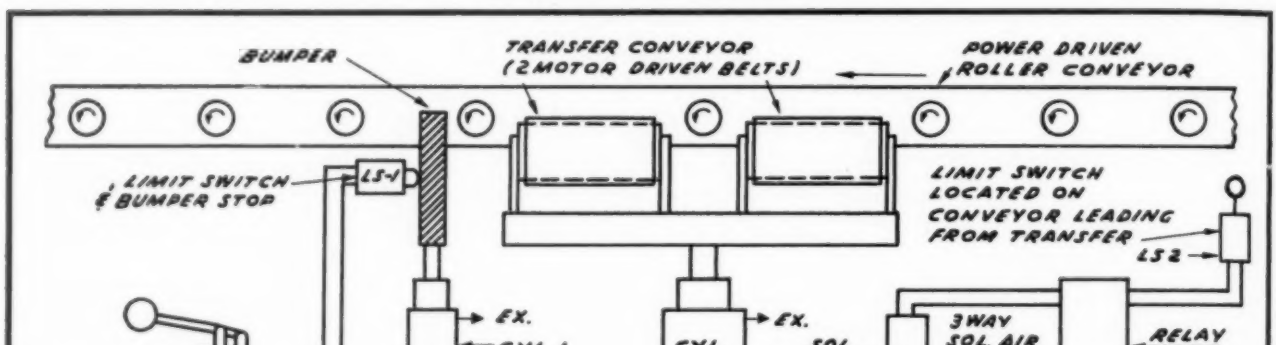
The roller conveyor in Figure 3 is power driven and the function of the air cylinders here is similar to that shown in Figure 2, namely to transfer products from one conveyor to another at

right angles to it. In this case, a separate transfer conveyor is used and consists of two motor driven belts which are placed between the rollers of the main conveyor and slightly below them. A bumper to the left of the transfer conveyor is placed between the rollers in the same manner. Normally, packages or boards, or whatever they may be, pass along the main conveyor and over the transfer conveyor and the bumper. In order to operate the transfer, the handle on the three-way air valve is pushed down, admitting air to hinged cylinder number 1 which pushes bumper up. An object moving along the roller conveyor contacts the bumper which in turn closes limit switch LS-1. The relay is closed which energizes the solenoid of the three-way spring return air valve, thus directing air to cylinder number 2 which raises the transfer conveyor, moving the object off of the main conveyor to an auxiliary conveyor. As it passes onto this latter, it opens limit switch LS-2 breaking the holding circuit in the relay and reversing the solenoid valve permitting the transfer conveyor to return to its original position by gravity.

This operation will repeat as long as the bumper is up. Reversing the hand valve will lower the bumper since it also is returned by gravity.

In the circuit drawing "air controlled automatic riveting cycle" in Mr. Schupner's second article (page 15, July issue) the line between the tonnage control top port and the check-starting valve line was omitted by error—EDITOR.

Fig. 3.
AIR CYLINDERS TRANSFER PRODUCTS FROM ONE CONVEYOR TO ANOTHER AT RIGHT ANGLES TO IT



ELECTRONICS NEED NOT SCARE YOU

(Continued from page 8)

gaseous type being the most sensitive but also the most critical. Anode current is proportional to light flux with either type. Consequently in addition to serving as "on-off" purposes such as the familiar electric-eye applications, they are also used for measurement of light intensity, color comparison and like photometric purposes.

A Complete Electronic System

Bearing in mind the above outline of the various electron tubes and their uses, what then constitutes an electronic control system? This question is best answered by an hypothetical example. Let us consider the problem of planning a device which would cause an electric fan to increase in speed as the sunlight in a room increased in intensity.

First, a means of continuously determining the strength of sunlight is required. A phototube in a measuring circuit fulfills this need.

The output from the phototube circuit is a current varying in proportion to the strength of the light, but it is too low to be of direct use in controlling the fan motor. This dictates the use of a pliotron amplifier which becomes the second unit of the system.

The output from the amplifier is a much greater current varying in relation to the light on the phototube but it is not practicable to apply this directly to the motor because a pliotron is characteristically a high voltage, low current device. The variable speed requirement necessitates a direct current motor. Thus a controlled rectifier, a thyratron, is indicated as a source of power for the motor; the output of the thyratron and in turn the motor speed being governed by applying the amplifier output to the thyratron grid. The third element then, is a thyratron.

The fourth unit in such a system would be a phanotron or kenotron rectifier for supplying direct current to the phototube and amplifier.

Some electronic systems are far simplier than this; others are much more complex. However, the great majority, like our example, lend themselves to analysis, unit by unit.

VALVE CONTROLLED SERVOMECHANISMS

NAVY ANNOUNCES HYDROLUBE DEVELOPMENT

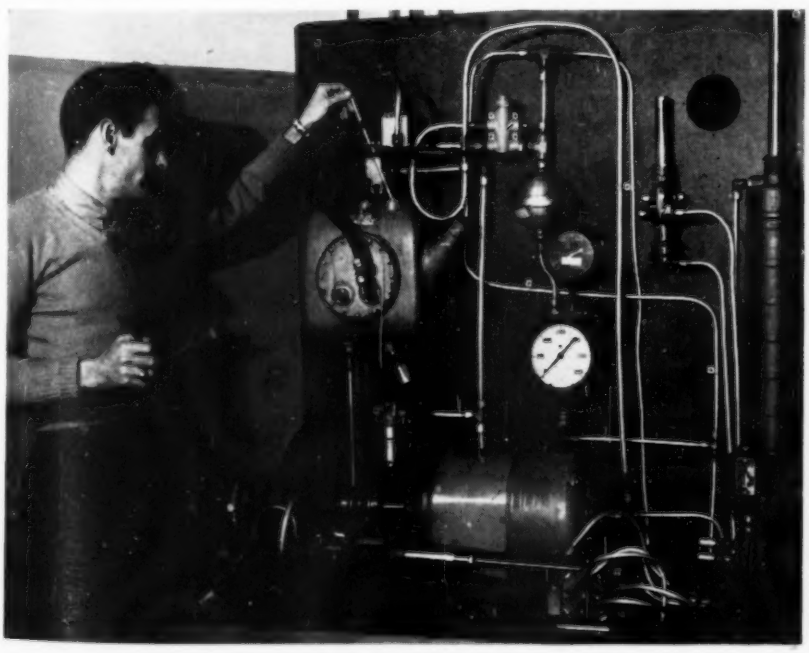
HYDROLUBE FLUIDS—so-named because of their water base and designed to eliminate the fire hazard resulting from the use of petroleum base fluids in hydraulic systems, particularly in aircraft, are now considered successful according to an announcement by Rear Admiral Paul F. Lee, Chief of Naval Research.

The development of the first noninflammable hydraulic fluids is the result of four years of systematic search by chemists and engineers at the Naval Research Laboratory for an answer to the serious problem of fires resulting from rupture of hydraulic lines. The first hydrolube fluid, designed especially for use in aircraft, but with many possible industrial applications, has the following characteristics: it will not burn; its freezing point is 82 degrees below the freezing point of water; it is much less corrosive than water; it provides much greater freedom from packing deterioration and leakage than present hydraulic fluids; its lubricating properties are satisfactory; and all ingredients are made of chemicals of native American origin.

The use of water base fluids in the landing gear, brake and flap control hydraulic systems of military planes will increase their combat efficiency by preventing fires caused by bullets or shrapnel puncturing high pressure hydraulic lines.

In addition, noninflammable fluids will give added safety to both military and civilian aircraft by eliminating a major fire hazard created by the rupture of hydraulic lines in emergency landings.

Fig. 1. A part of the test apparatus used in the development of the new Navy hydrolube. A low temperature bath is being used to determine the viscosity of a hydraulic fluid at –40 F. —Official U. S. Navy photograph



Although the hydrolube fluids have been tested in Navy planes for over two years without failures, the effort to improve them still goes on. In an aircraft mock-up, three different types of piston pumps are in constant operation pumping the hydrolube fluids through actual systems. After each 1000 hours, the systems are disassembled and all parts inspected for such performance indices as wear, corrosion and packing attack. To make the testing even more severe and reliable, each of the pumps in use demands a different type of lubricant; the fluids must meet all three demands. Ten hours of this testing is estimated to be the equivalent of 100 hours in normal aircraft operation.

The Navy Bureau of Aeronautics, which has sponsored the hydrolube development project along with the Office of Naval Research, has approved the water base fluids for use in the hydraulic systems in most types of Naval aircraft in the future. As the project developed, several industrial organizations, particularly the Ammonia Department of E. I. duPont de Nemours and Company, who assisted in the early formulations of the water base fluids and the Carbide and Carbon Chemicals Corporation, who made the polymer, an organic chemical that made all the ingredients soluble.

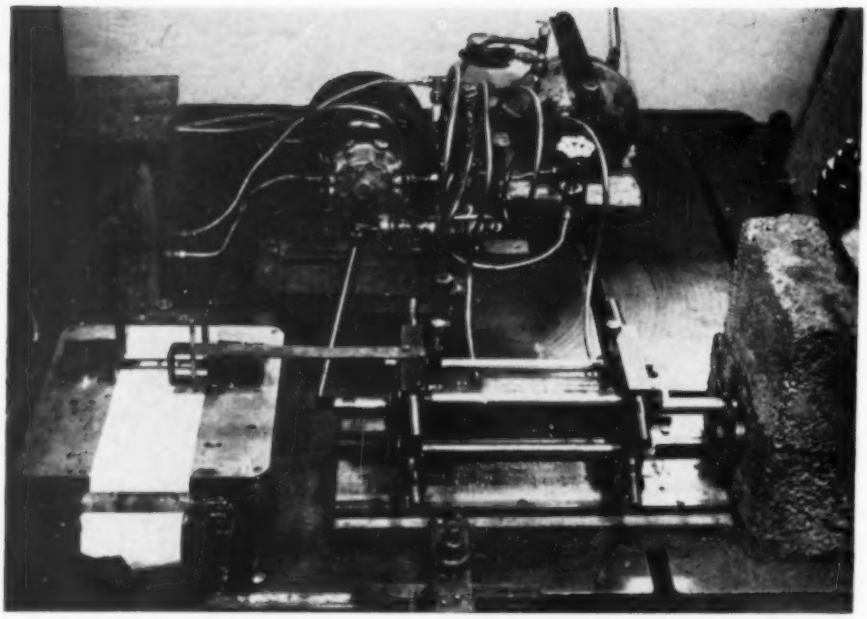


Fig. 3. Valve-controlled servo test setup for checking computed characteristics.

Photo—courtesy, Massachusetts Institute of Technology

VALVE-CONTROLLED SERVOMECHANISMS

The concluding half of a report on the analysis of the dynamic behavior of valve-controlled servo cylinders. The relationship between the movement, time and design ratios is shown; theory is checked against test results and the conclusions and recommendations for design are summarized.

IF S is the *desired* servo movement (signal) and x is the amount of recovery achieved at any instant t during the response, the valve piston will still have to move the distance

$$\frac{y}{z}(S-x) = r(S-x)$$

before it will reach its final neutral position. This gives the *length* of each port orifice opening, the *width* being

$$\sqrt{\frac{A_l}{2}}$$

since each orifice consists of two equal square openings. Therefore the valve opening (squared)

$$A_c^2 = 2r^2(S-x)^2.A_l$$

which is substituted to give

$$\frac{d^2x}{dt^2} = p_x \frac{A_c}{M} - \frac{\rho}{2} \frac{A_c^3}{Mr^2c^2A_l} \frac{1}{(S-x)^2} \left(\frac{dx}{dt}\right)^2, \quad (6)$$

in which $r = \frac{y}{z}$.

In order to make this equation and its solution generally applicable to the widest variety of servo proportions and conditions of operation, it is now put in non-dimensional or "ratio" form. This is accomplished as follows:

(a) dividing through by S

$$\frac{d^2\left(\frac{x}{S}\right)}{(dt)^2} = \frac{p_xA_c}{SM} - \frac{\rho}{2SMr^2c^2A_l} \frac{A_c^3}{\left(1-\frac{x}{S}\right)^2} \left[\frac{d\left(\frac{x}{S}\right)}{dt}\right]^2;$$

(b) letting

$$\frac{p\ A_c^3}{r^2 S M A_l} = K,$$

which is a design ratio (dimensionless);

(c) substituting K, so that

$$\frac{d^2\left(\frac{x}{S}\right)}{(dt)^2} = \frac{p_x A_c}{SM} \cdot \frac{K}{\underbrace{\left[\frac{p\ A_c^3}{r^2 S M A_l}\right]}_{K}} -$$

$$\frac{K}{2c^2} \frac{1}{\left(1-\frac{x}{S}\right)^2} \left[\frac{d\left(\frac{x}{S}\right)}{dt}\right]^2;$$

(d) dividing by

$$\frac{r^2 p_x A_l}{A_c^2\, p}$$

and cancelling out,

$$\frac{d^2\left(\frac{x}{S}\right)}{\left[d\left(\frac{t}{\frac{r}{A_c}\sqrt{\frac{p_x A_l}{p}}}\right)\right]^2} =$$

$$K\left\{1 - \frac{1}{2c^3} \frac{1}{\left(1-\frac{x}{S}^2\right)} \left[\frac{d\left(\frac{x}{S}\right)}{d\left(\frac{t}{\frac{r}{A_c}\sqrt{\frac{p_x A_l}{p}}}\right)}\right]^2\right\}$$

or

$$\frac{d^2 \Xi}{dT^2} =$$

$$K\left\{1 - \frac{1}{2c^2} \frac{1}{(1-\Xi)^2} \left(\frac{d\Xi}{dT}\right)^2\right\}, \quad (7).$$

This differential equation ex-

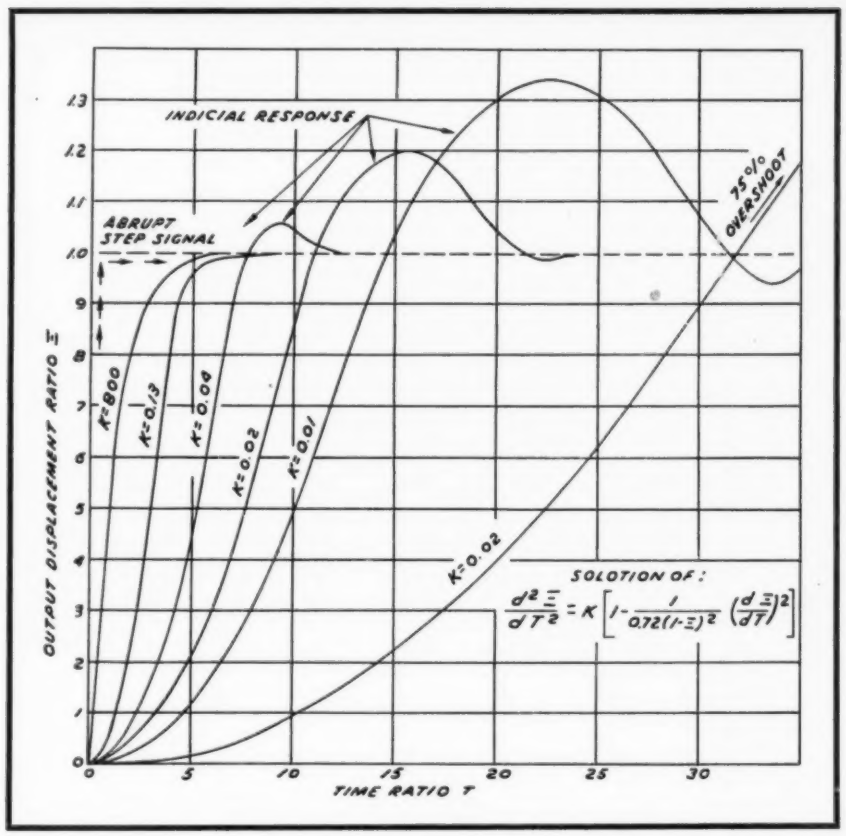
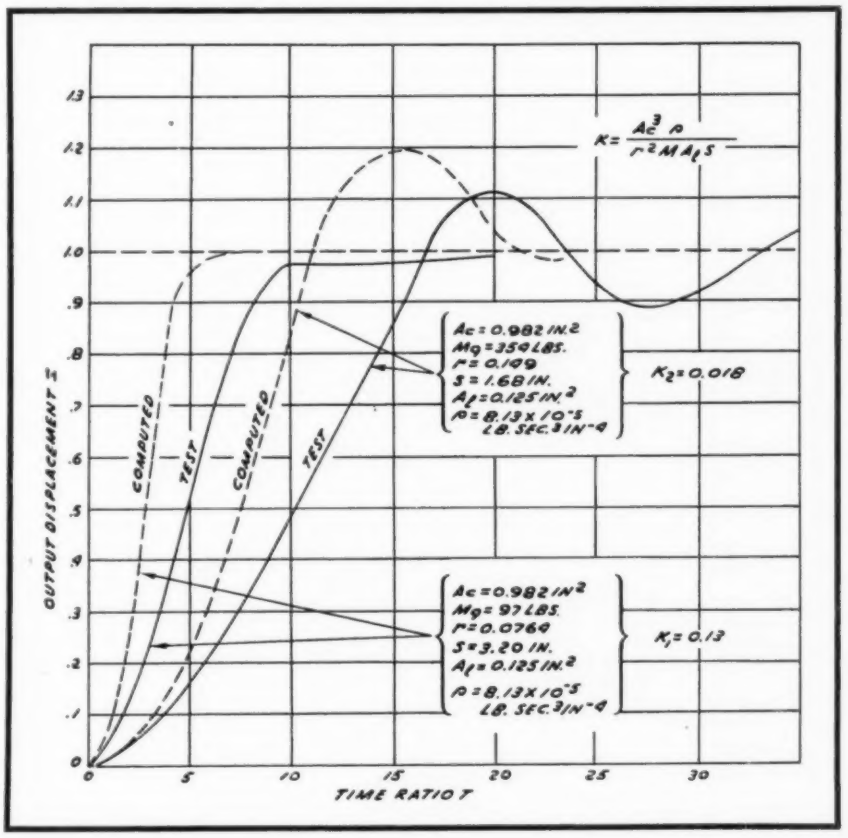


Fig. 4. Calculated dynamic behavior of valve-controlled servo.

Fig. 5. Comparison of computed curves with test results.



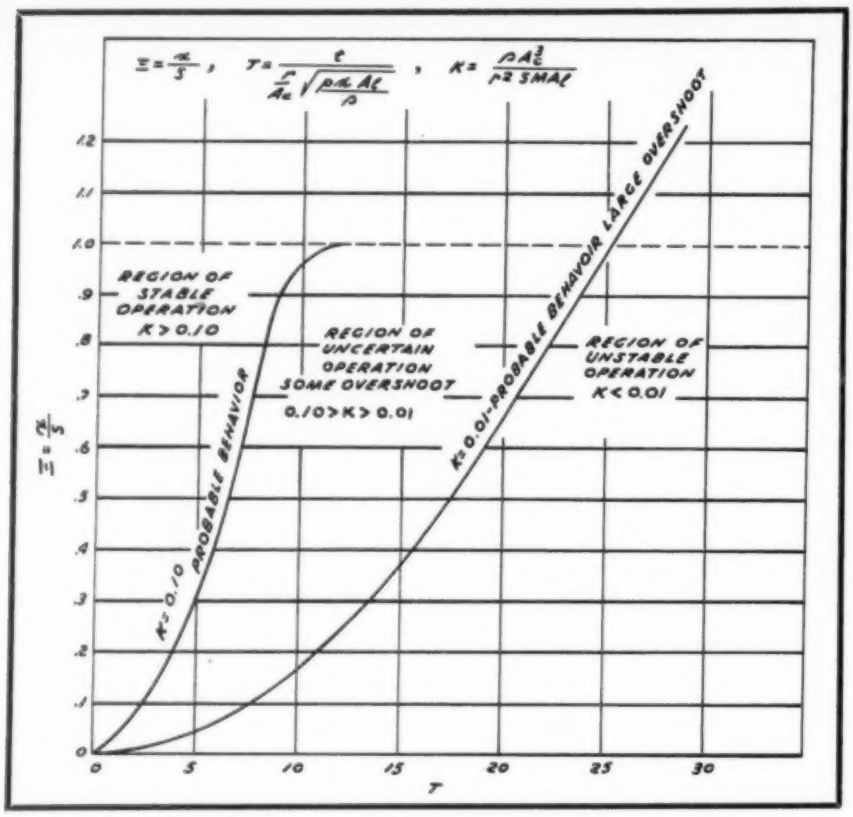


Fig. 6. Recommended design limits, with minimum recommended design ratio and indicating regions of uncertain and of unstable operation.

presses a relationship between the three "ratio" variables:

$$\Xi = \frac{x}{S}, \text{ the } \textit{movement} \text{ ratio;}$$

$$T = \frac{t}{\frac{r}{A_c}\sqrt{\frac{p_x A_l}{\rho}}}, \text{ the } \textit{time} \text{ ratio;}$$

and

$$K = \frac{\rho A_c^3}{r^2 S M A_l} \quad \text{the } \textit{design} \text{ ratio.}$$

The solutions which represent the position as a function of time as the servo responds to a demand (signal) for a change of position S with a given design are obtained by integration of the differential equation. The integration for various design ratios, as mentioned previously, have been carried out by step-by-step approximations. See reference 1. The details of this process are too involved to describe within the limits of this discussion. The results only are given in Figure 4.

The premises on which the solutions were obtained are summarized as follows:

(1) rigid structural parts and incompressible liquid;

(2) leakless piston seals at valve and cylinder;

(3) load resistance R_{load} always opposing motion;

(4) valve port area equal to line area and in two squares;

(5) maximum system pressure during retardation near, and at, neutral position of valve limited to $3p_x$, as by relief valves which are assumed to open for the designs which "overshoot".

The last condition has not been mentioned before and is necessary because of the assumed condition of leaklessness. It should be obvious that if the servo tends to "overshoot" its signalled position it will reach the closed position of the control valve with velocity. Then, if the valve closes tightly, all flow must be entirely shut off, which would cause an instantaneous deceleration of the mass, resulting in infinitely high pressures. In practice, of course, the condition of leaklessness is not achieved and the pressures are limited on this account. Probably the assumption of pressure peaks equal to or less than three times as high as p_x, the excess driving pressure, is fairly close to the actual condition in a reasonably tight servo.

The analysis of pressure variation in the systems under consideration indicates that if the servo does not overshoot, the maximum cylinder back-pressures reached during deceleration are less than twice the accelerating pressure p_x.

An examination of Figure 4 makes evident that the most rapid response is achieved by servos designed with the higher values of K and that this same trend in design conditions promotes greater stability (less tendency to overshoot and oscillate). The servos having K greater than 0.13 do not overshoot at all. Those having K as low as 0.002 appear to be near complete instability since the overshoot is 75 percent of the original signal. If it should be 100 percent, the oscillation would be unending. Of course, any greater overshoot than 100 percent represents complete instability, wherein the servo "runs away" with ever-increasing oscillations. Such a design is useless and must be avoided at all costs.

It must be emphasized that the curves of Figure 4 are "theoretical" to a degree, in view of the assumptions made. However, they reveal clearly the qualitative effect of changes in design relations, and when compared with the results of actual tests, suitable correction factors may be applied which will enable the designer to use them to advantage in predicting the probable behavior of an actual mechanism. Such a comparison with test results and recommendations for design follows.

Agreement of Theory with Test Results

In Figure 3 is shown a test setup with a servo system in which special precautions were taken for tightness at seal surfaces of the piston, valve and piston rod glands. The rods and pistons were sealed by long close fits in self-aligning glands, but without packings, so as to minimize the effects of friction. The valve was constructed with double square port orifices. The system was served by a gas pressure accumulator having a flexible diaphragm separating the gas and the working oil. Response was measured by a pencil tracing a path on a moving tape.

The results of two tests under widely different operating conditions are shown in Figure 5, in comparison with the corresponding "theoretical" curves taken from Figure 3. These tests were repeated many times to insure that steady conditions existed. It is to be noted that the *character* of the responses obtained for the design conditions of $K = 0.018$ and $K = 0.13$ are closely similar to those of the calculated curves (dotted lines), but that the actual response time in each case was longer by about 50 percent. In addition, it was observed that at the condition of $K = 0.018$, the system was near instability, and in fact, when reduced to $K = 0.01$ there was steady oscillation.

It may be observed from this comparison that in order to compensate for the effects of neglecting leakage, friction and elasticity in the computations, it is necessary:

(a) to increase the predicted time of recovery by at least 75 percent; and

(b) to apply a safety factor of approximately 10 to the design factor to insure freedom from instability, since the computed curves indicate 100 percent overshoot at $K = 0.001$ and the test servo demonstrated unending oscillation when K was approximately equal to 0.01.

Conclusions and Recommendations for Design

To clarify the results of the discussion in conjunction with the test observations, the following data may be set down in summary, as having been demonstrated:

(1) the valve-controlled servo is increasingly stable as the design factor

$$K = \frac{A_c^2 p}{Mr^2 A_1 S}$$

becomes larger and this means,

(a) that an increase in the cylinder area A_c is strongly beneficial in maintaining stability;

(b) that increasing values of either the system mass M, the response ratio r, the valve port area A_1 (assumed equal to the pipe line area) or the magnitude of the disturbance (signal) S cause tendencies toward instability;

(2) that a design ratio of $K = 0.10$ is probably the minimum at which it is safe to operate and that any increase above this value, obtainable within the other design limitations, is desirable;

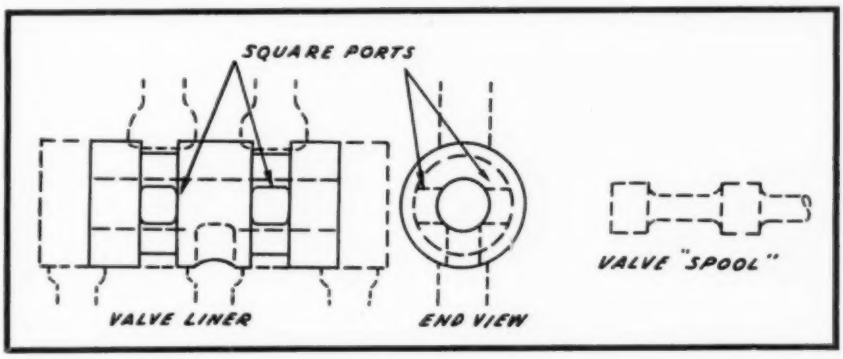
(3) that Figure 6 represents the probable "indicial response" performance of an actual servomechanism designed to the minimum recommended design ratio of $K = 0.10$; the other data indicate the variations in behavior to be expected at higher and lower values of K, as judged from the test results.

In addition to these conclusions, it is important to mention the qualitative effects of variations in control valve port design. As mentioned before, such valves are usually designed with a continuous circumferential groove in the valve cylinder bore, and usually have a "wide-open" area much greater than the area of the pipes connecting them to the other components of the system. In such case, a very small displacement of the valve piston exposes an orifice that is the equivalent of the line area. Consequently, the valve exercises little or no control during most of the motion and a marked tendency toward instability results. Also, this makes for increased leakage since more of the valve spool circumference is exposed in the neutral position to the differences in the system pressures.

The optimum design of a valve orifice consists in a pair of diametrically opposed ports cut through a valve bore liner and connected by a circumferential groove around the outside periphery of the liner, as in Figure 7. The ports need not, and preferably should not, exceed the

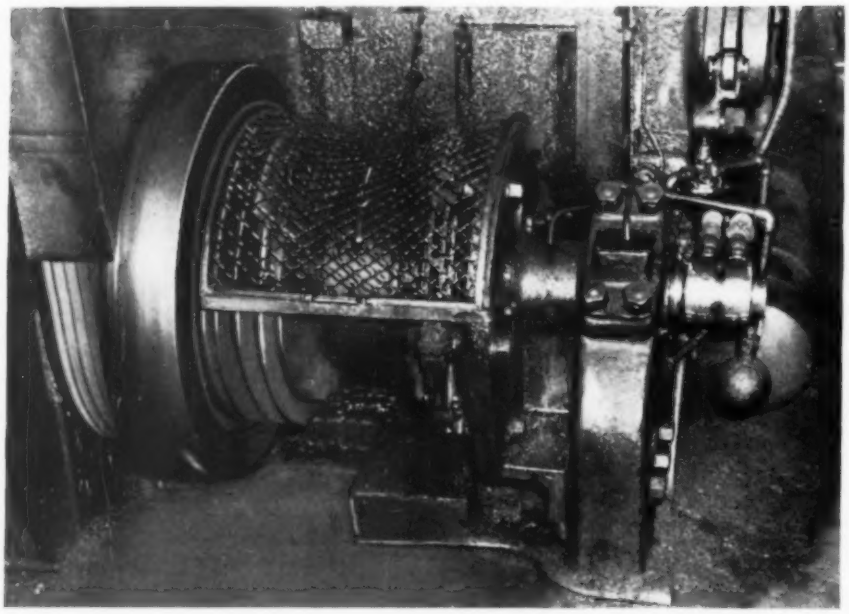
(Continued on page 22)

Fig. 7. Square ports arranged diametrically opposite in valve liner, broached through. Each pair of ports has area equal to area of connecting lines.



AIR POWER FOR

Fig. 1. Rear view of the forging machine showing drive, clutch, brake, air distributor, master four-way valve and clutch releasing cam.



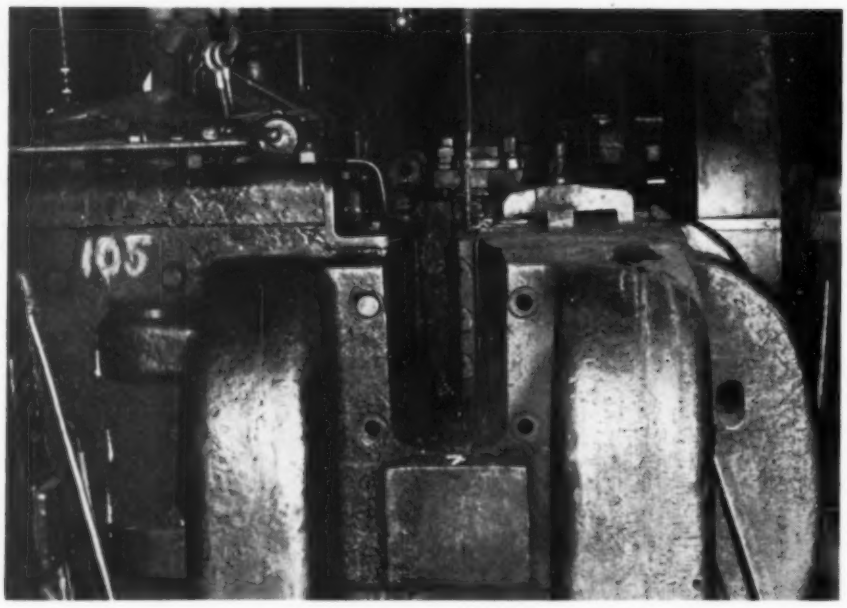


Fig. 2. The front of the same two-inch capacity machine showing the die area.

THE Hardware Division of the Upson Walton Company, Cleveland, produces a wide range of marine parts by forging. A large number of these are made on horizontal forging machines. On one machine, for example, of two-inch bar capacity over twenty parts including pins, rod ends, shackles, buckles and straps are made. A production rate of from 90 to 220 pieces per hour have been maintained without difficulty, a rate at least 20 percent higher than with older mechanical forging machines in the same shop.

Because of the type of work they do, forging machines operate under more adverse conditions and receive more unavoidable abuse than most any other class of machinery designed for long, uninterrupted service in the production of close limit parts. For this reason the Acme Machinery Division of The Hill Acme Company began in 1934 to experiment with the possibilities of using air operation. As the experiments progressed it became apparent that air operation, particularly in the simple positive control made possible by the operation of both a clutch and brake from a single, double acting air cylinder and piston, offered definite advantages.

The single, double acting air cylinder was used to provide a differential between clutch and brake, so that the brake cannot be set when the clutch is engaged and vice versa, the action giving a cushioned drive. This has resulted in higher production, reduced heat losses with more operations per heat, less maintenance and permits sensitive clutch engagement and dis-

MARINE PARTS

A forge shop making marine parts uses air operated forging machines to increase production, simplify die changes and reduce maintenance cost.

engagement at any position in the cycle to allow inching, which is advantageous in die setting.

The machine is built around an air operated clutch and brake. The drive, located at the rear of the machine, is through double gear reduction for increased power. The flywheel mounted on the pinion shaft contains the driving clutch mechanism; the brake mechanism is mounted on the opposite end of the pinion shaft opposing the clutch. The flywheel is the only rotating member when the machine is idling.

The double acting piston and cylinder is located on the pinion shaft between the clutch and brake. The cylinder is the moving member, the piston the stationary member. Cycle control is through a master four-way valve, spring loaded at one end, with air cylinder at the other end. When the operator steps on the foot pedal of a three-way air valve, air pressure from the supply source enters the control valve, compressing the spring and opening the port through the valve, passes through the air distributor on the end of the pinion shaft and an air passage in the shaft, forcing the cylinder against the driving clutch. This action carries the machine through its cycle.

At the completion of the cycle, the clutch releasing cam, mounted on the end of the main shaft, trips the master valve, porting air through the distributor and a second air passage to the brake side of the piston, forcing the cylinder against the brake side of the piston. This stops the machine in the open position.

The double acting cylinder permits cylinder travel to compensate for any wear on friction surfaces due to continued use. It also prevents drag on friction surfaces when transferring from clutch to brake. Air consumption is low since both clutch and brake actions operate from one cylinder. Operating pressures are also low. Most of the pieces forged in the Upson Walton shop use 80 psi or less.

The main shaft, with solid eccentric, permits a large bearing area in the sliding head—resulting in lower pressures per square inch and exceptionally low maintenance. Double cams on the main shaft move the toggle slide forward and back. The slide also contains the fully automatic safety relief which protects the machine from damage due to misplaced stock or other obstruction. Toggle levers, which act as safety links, are kept in a nearly straight alignment by a heavy, vertically mounted spring. If there is any obstruction in the die area, the safety links instantly assume an angular position, permitting the cam slide to complete its cycle by telescoping the link arm connection with the sliding box; the link arm connection remaining stationary due to the obstruction. On the cam slide return stroke, the spring returns the safety links to their normal position. This ability of the machine to go through a cycle without damage when the dies are obstructed has eliminated many troublesome production delays.

Loading and unloading is manual. Since the operator merely presses the foot switch to actuate a cycle, practically his entire attention is given to loading and unloading. The machine is protected by a centralized pressure feed lubricating system. The lubricating system motor is wired so that the pump motor must be started before the main motor can be started.

The automatic air operated machine has been in the Upson Walton shop for seven years, but because of the round-the-clock operation during the war years, superintendent Andrew Evans estimates that the machine has given the equivalent of approximately 12 years of normal service. In this time the machine has not required a major overhaul. Other than pins, no parts have had to be replaced due to normal wear.

A carefully kept individual machine maintenance record shows that this machine has been maintained at a cost of only fifteen dollars per month. This maintenance record is one of the lowest in the shop and is considered very satisfactory.

Die changes are normally made from one job to another in an hour to an hour and a half. The piece part runs average from one to five thousand, with the machine kept in steady production day after day. It is estimated that approximately three million parts have been forged on this machine to date.

Superintendent Evans summarizes the advantages of their automatic air operated forging machines as follows: increased production; faster, easier die changes; less wear on tools; longer machine life and reduced maintenance.

LETTERS to the Editor

Is the Hydraulic Institute active? We understand that the member companies are pump manufacturers only. Is there a trade association that includes manufacturers of other types of hydraulic equipment?

B.R.

As far as we know the Hydraulics Institute is active. This group held an annual meeting at Chicago in May which was attended by representatives of a majority of the nearly 40 member companies. According to secretary C. C. Rohrbach, the Institute members manufacture centrifugal, rotary and reciprocating pumps. We do not know of an association of manufacturers of other types of hydraulic equipment. For your information the address of the Hydraulics Institute is 90 West St., New York 6, N. Y.

Additional answer to "A.W.L." (July issue)

In addition to installation and service literature of manufacturers of hydraulic units and components, several manufacturers issue periodic house organs. Some of these carry excellent data that is directly useful to maintenance men. The names of several such publications with which we are familiar are being sent to you.

Answer to "J.T." (July issue)

The question in the July issue of APPLIED HYDRAULICS regarding the shrinkage of a hardened chrome moly sleeve about a tube by drawing up the nut implies that only soft steel or brass sleeves can be shrunk about the tube, as the tube is connected to the fitting.

The truth is that chrome moly steel sleeves hardened to 45 Rc can be shrunk about the tube even though some engineers may question this fact. Why such a hardened sleeve can be shrunk is not easily explained. In explaining this unexpected shrinkage some engineers claim it is due to metal flow; others believe it is due to buckling. The buckling theory seems to prevail since the wall thickness of the sleeve has a part to play, because hardened sleeves with a wall thickness of .044 with average torque applied to the nut would not shrink, whereas a hardened sleeve with .036 wall thickness did shrink about the tube. If the metal flow theory is the answer, why did the sleeve with a .044 wall not shrink?

D.B.B.

Answer to "G.N.R." (July issue)

The General Motors Joint Industry Conference on Hydraulic Standards for Industrial Equipment has been working steadily on this project for a number of months. The job has taken longer than first anticipated, due largely to the fact that more groups of manufacturers of specific types of equipment have been called into consultation. The latest information we have is that the Tentative Code will be ready for publication and distribution in the fall. It is our understanding that nomenclature and drawing symbols will be a part of the code.

This column is open to comments on general trade and technical problems. Comments are invited from our readers on questions or answers as published—EDITOR.

VALVE-CONTROLLED SERVOMECHANISMS

(Continued from page 19)

connecting lines in aggregate area.

If the valve orifice shape is necessarily different from the recommended pair of square ports the behavior may still be accurately predicted from the analysis results. This follows from consideration of the basis on which the orifice opening was introduced into the equation of motion. It may be recalled from the development of equation 6 that the instantaneous port area

$$A_o = 2r\,(S-x)\sqrt{\frac{A_1}{2}},$$

where A_1 was the total port area. Then when r(S-x) reached the value of

$$\sqrt{\frac{A_1}{2}}$$

the orifice is completely uncovered and $A_o = A_1$. From this it is clear that

$$2\sqrt{\frac{A_1}{2}}$$

represents the *total circumferential width* of the two ports. If the port shape is different from a square, the total circumferential width W may be substituted and this is equivalent to

$$W = 2\sqrt{\frac{A_1}{2}} = \sqrt{2A_1}$$

$$A_1{}^1 = \frac{W^2}{2},$$

Where $A^1{}_1$ is the value to be substituted in the design parameter K for the equivalent port area, regardless of a smaller pipe line area. This results in a conservative prediction of behavior. The actual smaller pipe line area tends to promote greater stability. For completely circumferential valve ports

$$W = \pi \cdot (\text{spool diameter}) = \pi d \text{ spool}.$$

In the case of the complete annular groove

$$A_1{}^1 = \frac{W^2}{2} = \frac{\pi^2 d^2 \text{spool}}{2},$$

which is approximately *six times* the cross-sectional area of the valve piston bore. Introduction of this equivalent large port area into the design parameter K clearly indicates the detrimental effect on stability. It may be compensated for by a corresponding reduction in the linkage response ratio r, but such correction does not eliminate the harmful effects which the large orifice area has on valve leakage, with its consequent promotion of instability.

It may be asked what effects are to be expected due to valve displacements from neutral which are greater than the orifice port length of

$$\sqrt{\frac{A_1}{2}}$$

upon which the analysis is predicated. Actually the error introduced is insignificant when the value of S used in K results in an abnormally large valve displacement, since the analysis upon which the curves are based fixes only the *width of the ports* when A_1 is established. Therefore the curves reflect a greater than actual port opening. However, at large valve openings the effect of such *differences* in valve opening on the pressure drop is negligible and the characteristic response curves shown may be used regardless of the relationship between S and A_1.

In a subsequent discussion it is intended to carry through a number of typical design problems in which the foregoing results are utilized and to demonstrate how the dimensionless characteristic curves may be used to predict operation pressures and the responses to constant velocity signals.

1. Insufficient or wrong grade of oil (too thick)
2. Air in the system

1. Proper functioning of prefill valve
2. Discharge from port (D) irregular because of line obstruction or operating valve too small

TROUBLE SHOOTING CHART

When the system does not develop full pressure, the cause may be:

1. Insufficient or wrong grade of oil (too light)
2. Air in system or entrapped in oil
3. Defective high pressure pump (blocked inlet)
4. Loose inlet to high pressure pump
5. Relief valve defective or not properly set
6. Port leakage in operating valve
7. Motor too small or defective; coupling or motor hooked up for wrong voltage
8. Cylinder cracked or scored
9. Leak in pipe line
10. Gland not drawn up square or loose
11. Gage defective
12. Check valve (6) not seated
13. Prefill valve not seated
14. Insufficient oil in prefill tank
15. Packings defective

When the system does not develop any pressure, check for:

1. Motor or coupling defects
2. Pumps not turning over or turning in wrong direction-blocked inlets
3. Adequacy of oil supply
4. Gage functioning
5. Proper functioning of operating valve (it may be in discharge position)
6. Breaks in pressure line
7. Proper rotation of motor—burned out fuse
8. Possible blocking of tank air vent
9. Position of prefill valve (open or not closed on down stroke)
10. Relief valve operation
11. Stop valve position (it may be closed)
12. Operation of the check valve

When full speed does not develop, the cause may be:

1. Insufficient or wrong grade of oil (too thick)
2. Air in the system
3. Pump or pumps defective or turning in wrong direction—inlets blocked
4. Unloading of low pressure pump
5. Operating valve too small or not at full opening
6. Improper seating of check valve
7. Defective relief valve
8. Gland loose or drawn up too tightly
9. Defective seals on piston head or rod
10. Flow control valve (9) not set properly—sticking—hole too small
11. Motor defective—wrong speed or hooked up for wrong voltage
12. Prefill valve too small or defective (does not open to fill cylinder on suction part of stroke)
13. Prefill tank too small
14. Mechanical bind in piston or cross head
15. Stop valve (14) not fully open
16. Air vent in oil tank or prefill tank too small
17. Too much friction in piping system

When down-stroke is irregular, up-stroke regular, check for:

1. Air in system
2. Insufficient oil in system
3. Defective prefill valve or connecting pipe
4. Discharge through cylinder port (E) may be too large
5. Loose gland or defective packings
6. Mechanical bind in piston or cross head
7. Low pressure by-pass valve (5), may be defective
8. Broken piston ring
9. Blocked air vent in oil tank
10. Opening of stop valve (14)
11. Operation of check valve (6)
12. Load center, it may be off center line of press
13. Displacement of pump, it may be too small

When up-stroke is irregular, down-stroke regular, check for:

1. Proper functioning of prefill valve
2. Discharge from port (D) irregular because of line obstruction or operating valve too small

HYDRAULIC CIRCUITS, IV

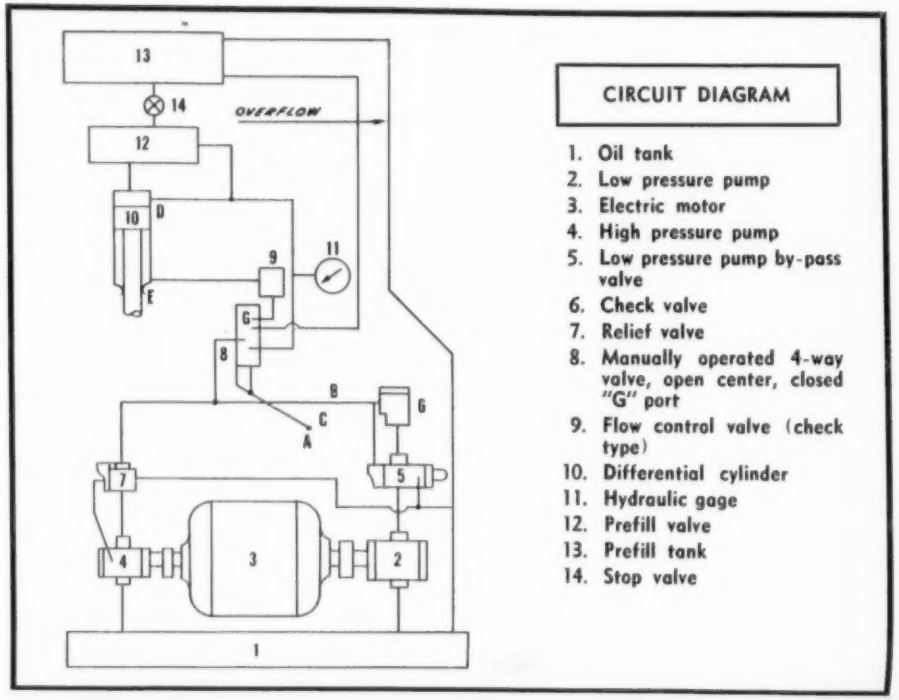
ACTUATION OF A DIFFERENTIAL CYLINDER BY USE OF TWO CONSTANT DISPLACEMENT PUMPS

By GEORGE N. DORR
Dorr-Patterson Engineering Company
Detroit, Mich.

CIRCUIT OPERATION

BY MOVING the operating valve lever of four-way, open center valve to position "A", the combined displacements of low pressure pump (2) and high pressure pump (4) enter cylinder (10) at port "D". This forces the piston down. Fluid displaced by this movement leaves the cylinder at port "E" and passes through flow control valve (9). A vacuum created by the downward travel of the ram is quickly ended as the oil from the prefill tank (13) passing through the prefill valve (12) is sucked in to fill the space behind the piston. The prefill valve then closes and the combined pump displacements actuate the piston.

When the line pressure reaches a predetermined value, the low pressure pump displacement is by-passed through valve (5) and further downward travel of the piston is actuated by displacement of the high pressure pump (4). When the operating lever of the valve is moved to position "B", combined pump displacement enters the cylinder at port "E". The piston reverses or retracts. Fluid displaced from port "D" by this movement returns to prefill tank through valve (8), unless the line pressure actuates valve (5) and by-passes pump (2). When the operating lever of the valve is moved to position "C", the combined pump displacements are diverted to prefill tank through valve (8) and the piston remains stationary if port "G" of valve (8) is blocked. Excess liquid in the tank (13) is returned to reservoir (1) by the overflow line. Check valve (6) protects pump (2) from over load.



CIRCUIT DIAGRAM

1. Oil tank
2. Low pressure pump
3. Electric motor
4. High pressure pump
5. Low pressure pump by-pass valve
6. Check valve
7. Relief valve
8. Manually operated 4-way valve, open center, closed "G" port
9. Flow control valve (check type)
10. Differential cylinder
11. Hydraulic gage
12. Prefill valve
13. Prefill tank
14. Stop valve

3. Loose gland or defective packings
4. Functioning on and off of by-pass valve (5)

2. Air in system
3. Mechanical blocking of moving members

flow line. Check valve (6) protects pump (2) from over load.

3. Loose gland or defective packings
4. Functioning on and off of by-pass valve (5)
5. Displacement of low pressure pump; it may discharge through operating valve instead of by-pass valve (5)
6. Mechanical obstruction of piston or cross head
7. Functioning of flow control valve (9); it may stick
8. Air in system

When both strokes are irregular, the cause may be:

(This action is to be expected with a single plunger pump)

1. Entrapped air in system
2. Excessive air in oil or wrong grade of oil
3. Leaks in the line
4. Gland loose or not drawn up square
5. Misalignment of piston or cross head
6. Defective pumps or loose inlet connections
7. A defective valve; check each of them
8. Defective piston rings or packings
9. Defective cylinder bore or piston
10. Blocked air vent in tank

When pressure builds up slowly, check for:

1. Air in system; air vent in tank may be too small
2. Prefill valve (12) may close too soon or it and its connecting piping may be too small
3. Pump capacity, it may be too small
4. Insufficient oil in prefill tank (13); means of preventing cavitation when piston is dropping
5. Proper closing of prefill valve (12); it must close so pumps can build up pressure
6. Opening of stop valve (14); it must open fully
7. Speed of piston drop; too large a port in flow control valve (9) lets it drop too fast
8. Proper functioning of operating valve (8)
9. Defective packings

When full stroke is not developed, look for:

1. Lack of oil in system
2. Air in system
3. Mechanical blocking of moving members
4. Pressure developed, it may be insufficient to move load

Air in the system may be due to:

1. Leaks in joints
2. Inlet to pump loose or too high
3. Oil level in tank too low or wrong grade of oil
4. Entrapped air in oil
5. Defective packings or loose gland
6. Cracked cylinder
7. Defective pump
8. Cavitation of oil in prefill tank on filling stroke

When system operates noisily, look for:

1. Entrapped air and lack of oil
2. Misalignment of pump and motor
3. Proper anchoring of pipe lines
4. Sudden release of pressure—valve may be too large
5. Vibration of pump or tank
6. Defective relief valve (7)
7. Defective pump (2 or 4)

When oil heats up, it may be due to:

1. Valves or pipe lines too small
2. Dirty, wrong grade or insufficient oil in system
3. Pump turning over too fast
4. Wire drawing in valves or seal on head of piston
5. Excessive amount of liquid being passed over relief valve
6. Too small an air vent in tank
7. Processing hot materials

Heating up of the motor may be due to:

1. Motor too small to carry the load
2. Low pressure valve (5) defective or not set at proper unloading pressure
3. Motor defective or hooked up for wrong voltage
4. Misalignment of motor and pumps
5. Lack of circulating air to cool motor

USE THE CORRECT OIL

There is no substitute for the correct grade of oil in a hydraulic system. Very few operational difficulties can be blamed on a hydraulic oil used on a specific job when the hydraulic manufacturers' recommendations are followed. However, when such recommendations, which are usually made by specifications, are not followed, the result is to invite trouble. This is particularly true if a stock of oil on hand is used regardless of its fitness or if an inferior grade of hydraulic oil is used.

The industrial division of a leading supplier of hydraulic oils had service calls from shops in which hydraulically operated machine tools developed troubles which were attributed to the oil used.

In one case a shop was operating a vertical turret lathe in which an inferior grade of hydraulic oil was used, for price reasons, for both hydraulic and lubricating service. The oil neutralization number reached 3.3 after 1248 hours of service. Severe deposits were formed in the system, requiring frequent shut-downs for cleaning. The direct substitution of a premium grade hydraulic oil resulted in a neutralization number of .80 immediately following installation, indicating contamination by dirty oil remaining in the system. Despite this, the final neutralization number of this oil was only 1.0 after 4335 hours of operation. No deposits occurred, greatly reducing the down time of the machine.

In another case the stock-moving units in a heat-treating furnace are activated by hydraulically actuated pusher rods. The hydraulic system developed 250 psi by means of a vane-type pump. Operating temperatures varied from 120 to 130 F. With an ordinary grade of hydraulic oil in service, deposits formed on the solenoid operated control valves, causing them to stick.

The substitution of a premium grade hydraulic oil eliminated the valve deposits, resulting in trouble-free service.

On the other hand, a hydraulic oil may be blamed for trouble which may be due to an improperly balanced circuit, e.g., operation with improperly set relief valves. In a third case, a shop was operating a large group of internal grinders in which severe deposits in the hydraulic control valves were causing excessive down time and lost production. The hydraulic oil was blamed for the trouble, despite the fact that a high quality product was in service.

Examination of the hydraulic circuits revealed operating temperatures of the oil to be 150 to 160 F, instead of the 120 to 130 F range which is normal for these machines. The pressure relief valves were found to be set for 400 psi, instead of 125 psi as recommended by the machine builder. Correct setting of the relief valves dropped the oil temperature down to the normal operating range and no further valve deposits occurred.

Another operating factor often overlooked is the ambient temperature of the shop. In a fourth case, a large hydraulically operated plate planer was installed in a steel shop where the ambient temperatures were within 5 degrees of outdoor temperatures.

A high viscosity, high quality hydraulic oil, as recommended by the builder, was in service the year around. In the wintertime a portable stove was set adjacent to the hydraulic oil reservoir and an hour was required each morning to warm the oil sufficiently to permit the hydraulic pump to handle it.

A properly selected oil of lighter viscosity, with good properties of low temperature pumpability, was substituted for cold weather operation. This completely eliminated the need for the stove and added one hour of production time daily.

When the proper, recommended grade of hydraulic oil is used, whether for machine tools or industrial equipment of any type, there are few difficulties that can be attributed to the oil itself. By checking through the elements of their hydraulic circuits and following the manufacturers' recommended procedure, the maintenance department can usually run down operational difficulties quickly and accurately.

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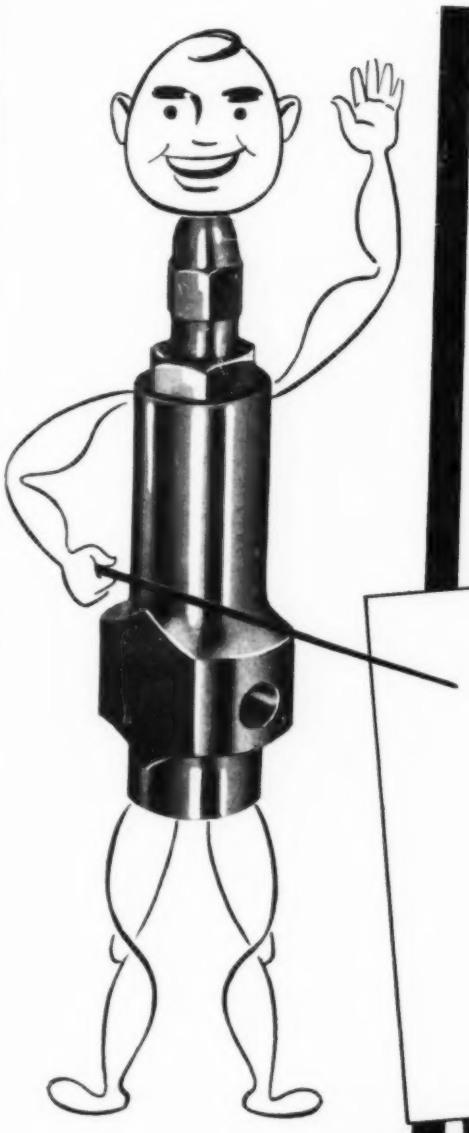

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Applied HYDRAULICS DIGEST

Abstracts, summaries and listing of articles on hydraulic and associated applications in industry; reports on prepared papers, talks and discussions of special interest to the hydraulics field.

Resistance Welder Plus Air Cylinders Equals Cutoff Machine

Lester Tingley, *American Machinist*, v 92, August 12, 1948, pp 120-121.

Bendix Products Div., Bendix Aviation Corp., make a novel use of sections of a flexible steel cable as stems for diaphragm-operated poppet valves which control Hydrovac power cylinders. To prevent the 0.128 in cable from unwinding, a specially redesigned resistance welder is used to both separate individual stems from the reel of cable and for welding the ends.

Four air cylinders on the cutoff machine are controlled by solenoid valves actuated by limit switches and electronic heat-control timer. In the automatic cycle, a horizontally mounted air cylinder moves a slide to feed the cable into clamp jaws; when the slide contacts a Microswitch, two vertical air cylinders clamp jaws onto the cable. One of the clamp cylinders operates a Microswitch at the bottom of its stroke to start the heating cycle. This is done by passing current through the cable between the jaws. At the end of the heating cycle, section between jaws is at fusion temperature. Then the fourth air cylinder, horizontally mounted and opposite the first cylinder is actuated by its solenoid valve, moving the right-hand jaws 0.020 in to the right, breaking off the stem section. At the end of the cycle all cylinders return to their original positions and automatically initiate the next cycle.

New Electronic Device

Anonymous, *Machine Design*, v 20, August, 1948, pp 95-96.

A new electronic device capable of performing nearly all the functions of an ordinary vacuum tube has been developed at Bell Telephone Laboratories. It is known as a Transistor and though it bears little physical resemblance to an electronic tube, this device functions as an amplifier or an oscillator. Two hair-thin wires touching a pin head of a solid semi-conductive material, soldered to a metal base, are the principal parts of the unit. They are enclosed in a metal cylinder no larger than a shoelace tip. Tests show that this device will amplify 100 times at a frequency of up to ten million cycles per second; test models have been used successfully in radio and telephone equipment.

Sheet Metal Operations

Anonymous, *Steel*, v 123, July 26, 1948, pp 97, 100.

Precision aircraft assemblies produced at Rohr Aircraft Corp., Chula Vista, Calif., are for the most part air controlled and operated. Time and money saving factors are evident in over-all results because of the use of this operating medium.

Four air compressors are used to produce the necessary pressure and they are located at a central point in the plant. The operating pressure obtained is 100 psi. One unit has a capacity of 628 cfm, two others have capacities of 426 cfm each and the fourth has a capacity of 380 cfm.

Several examples of the types of jobs performed by air power in this typical sheet metal plant are reviewed in this article. High speed drilling, air cushioning of mechanical presses, agitating of chemicals and a unique application for air distribution lines are included.

Operating Characteristics of Industrial Solenoids

Charles R. Underhill, *Product Engineering*, v 19, July 1948, pp 86-91.

A survey of the general characteristics of solenoids in terms of commonly used types; the designs of ac and dc solenoids are discussed. The differential action of a typical coil-and-plunger is stated as the difference between two opposed mechanical forces simultaneously attempting to move the complete plunger in opposite directions; the plunger being magnetized by current flowing in the coil, is pulled into the core hole by the predominating magnetic attraction until its middle coincides with that of the coil and the two opposed mechanical forces balance each other. This action occurs regardless of the relative lengths of plunger and coil. The mechanical force is proportional to the rate of increase in the linkage of current and magnetic flux, as the plunger moves into the coil. Virtual displacement is not always practical because of the incomplete linkages of current and flux and changes in permeability. For example, any linear motion between the current-carrying coil and the plunger of a dc solenoid generates a counter-emf which reduces the effective current strength of the constant voltage dc coils. For this reason the pull of dc

coil-and-plunger is greater with a slow moving plunger than with a fast moving one.
Special pull characteristics are outlined. The effects of slight displacement, the use of mechanical stops and the air gap pull are discussed. Design features, including formula for maximum pull and static pull characteristics of static pull of constant current and constant voltage ac and dc solenoids are illustrated by diagrams and methods for modifying pull characteristics are given. The article is the first of a series on the subject.

Hydraulic and Air Units Power Machine Elements

L. W. Court, *American Machinist*, v 92, August 12, 1948, pp 83-86.

Hydraulic and air power has been applied successfully not only in modernizing old equipment but also in the building of special equipment at the Richmond Works, Farm Implement Division, International Harvester Co. Power units are usually assembled from purchased elements. Whenever possible, pumps, drives, valves and reservoirs are mounted outside the machines they serve to simplify maintenance. Low-pressure systems are preferred and used whenever there is space to mount a low-pressure cylinder larger enough to do the job at hand. Pressure ranges average from 200 to 500 psi and rarely go over 600 psi. Hydraulic circuits usually are arranged for an automatic machining cycle. Pneumatic cylinders are used to some extent but are limited due to fact that pressures in the shop air line occasionally vary sufficiently to influence the proper functioning of machine elements.
Among the hydraulic and air circuits set up in this shop to modernize and improve production are the following: (1) hydraulic cylinders, vertically mounted over a special deep hole drilling machine with two inverted spindles, feed the work, which is mounted on vertical slides, against the drills; (2) three hydraulic cylinders clamp the workpiece and advance the drillheads in a special center-drilling machine. One control lever actuates all three cylinders; sliding heads are moved by cylinders integral with housings; (3) seven hydraulic cylinders, mounted under the base of a punching machine, pierce seven holes of different sizes in a can section of 0.035 in sheet steel; (4) a horizontal spindle drilling machine was equipped with automatic indexing and drilling circuits by the installation of three hydraulic cylinders. One cylinder moves the drillhead, a second turns the index wheel and the third locks the index wheel in each position; (5) a hydraulic cylinder equipped with an engaging lug at the end of its piston was mounted on a drilling machine to turn an index wheel one notch by sliding forward; to accommodate various size index wheels flexible hose lines connect some valves and cylinders to permit adjustments for

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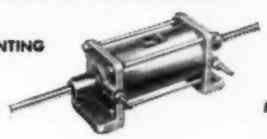

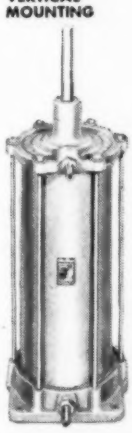

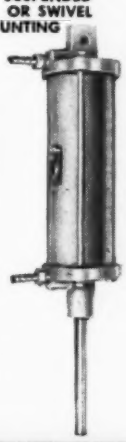

Mounting	Bore				
Horizontal	1½"	2¼"	3"	4"	5"
Vertical		2¼"	3"	4"	5"
Face		2¼"	3"	4"	5"
Swivel		2¼"	3"	4"	5"

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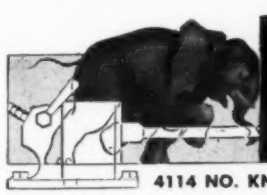

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AIR CIRCUITS SMOOTH PRODUCTION

At the Thompson Can Company, Dallas, Texas, air is being used for gaining better control of two operations in the making of cans. In the first operation cans of approximately three gallons size were slow in ejecting from a cone crimping machine. This slowed down production. The difficulty was overcome by supplying a blast of air to help boost the cans out of the machine. A one piece cam, operated by a three-way control blow valve and pilot valve, is actuated by the manual movement of a solid angle type lever after crimping.

The air blast has eliminated the ejection delay and permitted production to the full capacity of the crimping machine.

The second operation was for the control of the speed of the cans as they moved down a chute from one machine to another which put the bottoms on the cans. The cans would bump each other so hard that there was quite a loss from cans being bent and knocked out of round.

This condition was corrected by installing a wedge in the conveyor line to prevent cans from piling up. An air cylinder was used to operate the movement of the wedge to allow one can at a time to move down the chute. An air cylinder of the push-pull type, timed with a 110 v solenoid operated valve was installed. Several copper fins were fastened to the side of the chute close to the machine. As the operator lifts a can from the chute to put it in the machine, the copper contacts energize the solenoid valve, causing the air cylinder to pull back the wedge and allow another can to move down the chute. This operation is reported to be working very satisfactorily.

Pump Standardization Increases Interchangeability of Wearing Parts

The Aldrich Pump Company, Allentown, Pa., has standardized the design of their 6, 7, 7½ and 8 in stroke high pressure pumps to permit the use of identical wearing parts such as bearings, crossheads, wrist pins and valves, regardless of plunger diameter and the number of plungers. Increases in capacity are accomplished by increasing the number of pumping units. Pumps are supplied with 3, 5, 7 and 9 plungers.

In the 6 in stroke line, the Triplex has a 300 hp rating, the Quintuplex a 500 hp, the Septuplex a 700 hp and the Nonuplex a rating of 900 hp. The 7, 7½ and 8 in stroke pumps carry ratings from 1300 hp to 2400 hp.

Ring joint construction to all flanges can be incorporated and stuffing box linings can be provided if interchangeability of plunger sizes is desired.

---

wheel changes; (6) a double-acting air cylinder was installed on the tailstock of a trimming lathe to both minimize operator fatigue and speed production; (7) an air cylinder was installed on the top of a beading machine to hold beading rolls together after part has been inserted against gage plate. Double-acting, the cylinder is operated by a foot valve; and (8) a standard Sundstrand lathe on which carbide turning with two tools was done was revised for hydraulic feed and tool relief. At the end of the turning stroke, reversal of feed cylinder actuates a second cylinder under the cross-slide to withdraw tools from the work while the carriage is returned to start. Longitudinal traverse pressure is 600 psi. The tailstock spindle is air cylinder operated.

Air Fixtures Ease Machining and Assembly

R. E. Whinrey, *American Machinist*, vol 92, July 15, 1948, pp. 92-95.

For several years air cylinders have been applied to high production machines at Dodge plant of Link-Belt Company, with highly satisfactory results. This article reviews the advantages of air clamping and shows several of the setups used at this plant. Experience has shown that air clamping is faster and less fatiguing than conventional mechanical methods and, except for variations in line pressure, the clamping pressures are the same for each setup. Also the air fixtures at this plant have more than paid for themselves in a short time.

Hydraulic Valve Lifters

Anonymous, *Machine Design*, v 20, August, 1948, pp 144-146.

To maintain zero clearance between rocker arms and valves and thus insure quiet operation and accurate engine timing, hydraulic valve lifters are used in the 1948 Harley-Davidson motorcycle engine. The lifter consists of plunger operating in a cylinder with a controlled leakage between the two parts. Top end of the plunger contacts the rocker arm while the lower end of the plunger contains a check ball that controls oil flow into the unit. A snap ring at the top of the cylinder serves as a limiting force to the plunger travel, preventing it from being pushed into the cylinder head.

In operation, the plunger is pressed against the cup of the rocker arm by spring pressure; the other end of the rocker arm is in contact with the engine valve. Oil is fed from the center of the rocker arm shaft through a hole down through the center of the plunger. When the check ball is forced onto its seat by the upward movement of the oil, the entire valve mechanism is lifted. When the tappet reaches the base circle of the cam, the load is released from the hydraulic unit, the ball leaves its seat and the clearance chamber is replenished with an amount of oil equal to that which has escaped between the plunger and cylinder.

WHAT TO DO BEFORE THE SERVICE ENGINEER ARRIVES

The Taylor-Winfield Corporation, Warren, Ohio, manufacturers of resistance welding equipment, are using a pocket-size booklet, "What To Do Before The Service Engineer Arrives" that has been useful in reducing the number of service calls for insignificant or trivial causes. The booklet lists eight simple inspection checkups that often run down minor difficulties and which can usually be corrected on the spot by the operator or the shop maintenance man. Every factory and branch or distributor service man has made emergency calls to hook up a motor so that it will rotate in the proper direction, to connect air or water lines or other similar "jobs" that left some otherwise competent persons with very red faces.

We pass the idea along to manufacturers of hydraulic structures and components. A similar leaflet with a few check points based on an analysis of their own service calls may also reduce the number of "emergency" calls, especially those made where hydraulic equipment is new or where the experience of maintenance personnel with hydraulic elements is limited.

Why Pneumatics?

Harvey F. Gerwig and Joseph F. Famme, *Machine Design*, v 20, July, 1948, pp 138-142.

Part II of a two part article on the pneumatic system developed for the jet propelled XB-46 high speed bomber built by Consolidated-Vultee Aircraft Corp., San Diego, Calif. This installment deals with the development and research work done on this successfully tested system. After consideration of electrical, hydraulic and pneumatic systems, it was found that the time requirements for gear retraction bomb bay door operation could be satisfactorily met with an appreciable weight saving by using the pneumatic system. Charts and curves show the advantages of the pneumatic system.

During the early months of 1945 the pneumatic equipment manufacturers were asked to submit specifications and drawing of the units available to meet the requirements of this system. A 28-volt dc electrically-driven compressor with a discharge pressure of 1250 psi, hand and solenoid operated selector valves for pressures to 750 psi, pressure regulators designed to 1000 psi, relief valves designed to 500 psi and accumulators designed for 1250 psi storage pressure were purchased. Test work began on the landing gear setup.

Difficulties arose and it was soon evident that much research would be required. Rubber seats were discarded for use in the selector valves as it was found that they could not operate satisfactorily at 1000 psi because of sticking. A paraffin impregnated rubber was substituted. The pressure regulators were too small and special units of larger capacity had to be built on order. Hydraulic snubbers were found necessary to cushion the main landing gear during extension and to function as an emergency unit in case of failure of the pneumatic system; an oil-air accumulator provided pressure. Brake valves had to be redesigned, compressors were increased in capacity; pressure accumulators had to be entirely redesigned by the authors.

National Conference on Industrial Hydraulics

The fourth National Conference on Industrial Hydraulics, sponsored by Armour Research Foundation and Graduate School of Illinois Institute of Technology, will be held at Hotel Sheraton, Chicago, Wednesday and Thursday, October 20 and 21. An outstanding program has been arranged. Technical sessions are scheduled for both mornings and afternoons. Midday luncheons both days will hear additional general and technical problems discussed. Reports on the General Motors Tentative Code on Hydraulic Standards for Industrial Equipment will be made. A banquet will be held on Wednesday evening.

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Useful Literature

The publications listed are available without charge. Mark the initial key number on the card bound in this issue and mail.

25. Hydraulic Combinations . . . Oil hydraulic combinations in compact, easy-to-install units are described in a bulletin now available from Hydraulic Equipment Company. The units of this series, PVT 100, consists of a pump, tank, control valve and built-in relief valve. The pump is of the gear type and is available in either 2.25 or 4.5 gpm capacity for 1000 psi service; the control valve is offered in one or two plunger, single-or double-acting types for any sequence; and the tank capacity is 0.4 gal for PVT 100A group and 0.8 gal for PVT 100B group. For mounting, four tapped holes are provided in the base of the tank. Photographs and design drawings are included in this bulletin.

26. Hose Couplings . . . Catalogue No. 48-A reviews the hydraulic couplings and accessories produced by Eastman Mfg. Company. Couplings, hydraulic and air, inserts, adapters, hose and special assemblies are presented in this 40-page catalog. Of interest in a special assembly section are the "Snap-Tite" couplers for air hose. Each item is shown with a photograph and complete specifications. An index and sections on how to assemble couplings and on how to order them are also included.

27. Hydraulic Follow-Up . . . Askania Regulator Company describes in Bulletin No. 128 the air-coupled hydraulic follow-up they have developed to perform complex mechanical actions at high power when the initial action imposed on the system is at low power. This unit applies to situations requiring cams; the unit is built around this company's jet pipe principle. This bulletin tells what these units can do and how they work. A simple line diagram is included.

28. Liquid Handling Pumps . . . The gear, centrifugal and rotary vane type pumps, produced by Lobee Pump & Machinery Company, Inc., are described in a bulletin issued by this company. The bronze gear circulating pumps are available with pipe size connections from $\frac{1}{8}$ to $1\frac{1}{2}$ in, the rotary pumps $\frac{3}{8}$ to 1 in and the centrifugal pumps from $\frac{1}{4}$ to $1\frac{1}{4}$ in with capacities from $1\frac{1}{4}$ to 35 gpm.

29. "Clean Oil" . . . A quarterly publication issued by Honan-Crane Corporation which presents case histories of all types of oil cleaning problems, including the purification of hydraulic oils, in terms of installation and results. Volume 2-Number 3 of this publication is of special interest as it reviews a number of hydraulic cases involving injection molding presses, hydraulic presses, milling machines and other industrial machinery. Numerous other bulletins and information on the purification of various oils are also available from this subsidiary of Houdaille-Hershey Corporation.

30. Linear Moulded Seals . . . A 40-page handbook of design and installation data on the "O" rings and gaskets, V-ring packings, fabric reinforced V-packings and U-cup packings made by Linear Incorporated. Cross sectional drawings and tables giving full specifications are included. There are also sections of drawings of typical installations and reference data which includes diagrams of relative effect of various pressures and various groove designs on "O" rings and the new standard surface roughness, waviness and lay. Bulletin No. 32C, giving the current list of compounds of synthetic rubber stocks for moulded shapes available is also obtainable on request.

31. Air Actuated Clutch . . . The Air-Tube Disc Clutches produced by Wichita Falls Foundry & Machine Co. are described and shown in Bulletin No. 101. This clutch is a simple, compact troubleproof friction clutch that combines all of the advantages of air operation-remote control, small pressure for full torque, smooth starting and controlled torque. Capacities range from 32 to 450 hp per 100 rpm at pressures of either 80 or 100 psi. A cutaway and a specification drawing in addition to capacity and dimension charts are included.

32. Quick Couplings . . . A seven page condensed catalog featuring the stock models of the Inst-O-Matic coupling for fluid and air lines is available from E. B. Wiggins Oil Tool Company, Inc. Included are suggested uses already proven in industry and stock items and list prices in addition to lists of national users. Of interest is the Special Equipment Division offering custom modifications. The stock models are furnished $\frac{1}{8}$ to $\frac{1}{2}$ in hose size.

33. Solenoid Valves . . . The electrically operated valves for automatic or remote control produced by Atkomatic Valve Co., Inc. are reviewed in Folder No. 1-48. Incorporating line pressure as the main actuating force these valves are offered in sizes ranging from $\frac{1}{4}$ to 3 in for pressures to 3000 psi. Water, air and oil applications are recommended. Illustrations of each type of valve and descriptions of their construction and applications are included.

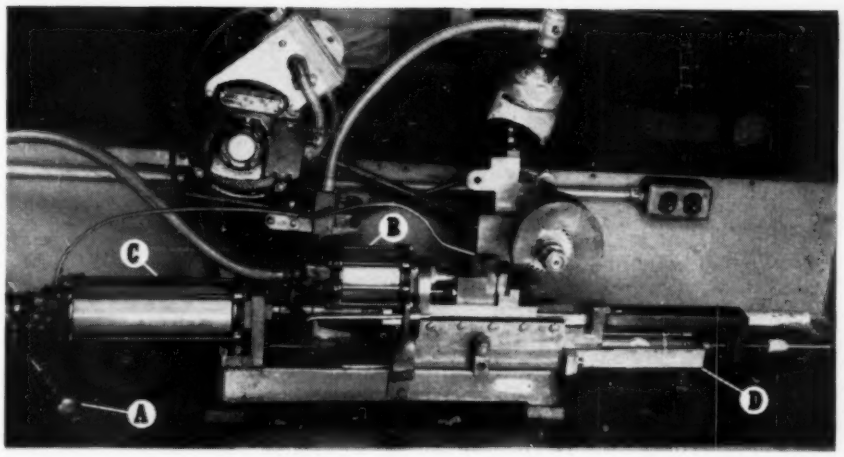
34. Air Filters . . . The Poro-Stone air filters produced by R. P. Adams Company, Inc. are described in a four-page folder. These filters can efficiently remove oil, water and pipe scale

from compressed air. Centrifugal separation and diffusion are utilized. Units range from ⅜ to 4 in pipe size for operation on air lines to 150 psi. Pipe line intercoolers and separators for air lines are also described. Design drawings and dimensional charts are included.

35. Relays and Actuators... Catalog No. 7 on Phil-Trol Relays and Bulletin No. 6 on Phil-Trol Actuators are available from Phillips Control Corporation. The 12-page relay catalog illustrates and gives specifications of the 8 types of relays made by this company. They include long and short coil, ac and dc telephone types, power type ac and dc and power and sensitive types for applications where severe vibration is encountered. The 8-page bulletin describes the five types of actuators that meet most solenoid requirements. Comparative pull charts and volt ampere curves for both intermittent and continuous duty are included.

36. Control Valves... The lever, solenoid, foot and motor operated valves offered by W. H. Nicholson & Co. are reviewed in Catalogue No. 546. They are of flat disc design in 2, 3 and 4-way types for air, oil and water service. Lever operated types are available in ¼ to 2 in sizes for pressures to 5000 psi; foot operated types for pressures to 300 psi; solenoid operated for pressures to 375 psi. Design drawings, price and dimension charts are included.

37. Pipe and Tube Bending Handbook... A 48-page booklet, issued by Copper & Brass Research Association is a very useful treatise on the practical methods for bending pipe and tubes of copper, brass and related alloys. The new third edition has been completely revised. The principles of bending, bending devices, principles of bending machines, commercial types of bending equipment are treated briefly but authoritatively with numerous illustrations. There is a final section on wrinkle bending.



TOOL ROOM INGENUITY INCREASES PRODUCTION

A RECENT production run on brass dial shafts at Ranco, Inc., Columbus, Ohio, was not sufficiently large to warrant the use of automatic machines. Yet, the cost of deburring the end and milling the shoulder of each shaft by hand was too high.

To solve this production problem, Ranco's tool room designed and built the small, inexpensive, special purpose unit shown in the illustration. Incorporating two air motors and a hydraulic resistance unit, this unit jumped production to over 800 shafts per hour, held operator fatigue to a minimum and reduced part cost by 31 per cent.

When the valve operating lever (A) is depressed, the piston of air motor (C) advances the table and at the same time operates the valve of air motor (B) clamping the part in the vise. The rate of feed of the table is controlled by the hydraulic resistance unit (D) which, also, minimizes any backlash and chatter that might cause tool breakage or excessive rejects. As the table returns, the vise opens automatically and the exhaust air from (B) ejects the part into a chute leading to the bin below. The exhaust air from (C) is used to keep the work area clean.

The air motors are non-rotating, double-acting power units with built-in valve, valve operating controls and independent piston speed controls. The hydraulic resistance unit is adjustable in one direction only and eliminates the natural "springiness" or "bounce" of air.

It was originally planned to further improve the unit by making operation of the valve operating lever (A) semi-automatic but it was found that production was sufficiently high and fatigue so slight that the automatic feature was considered unnecessary.

Tool room built, inexpensive special purpose machines are often the answer to production cost problems where the job run is too short to justify factory built special purpose equipment. The unit built at Ranco, Inc., as at many other forward looking plants, used air equipment because it was found that their low cost, ease of installation and simplicity of operation made construction of this special purpose machine quick and inexpensive.

38. Air-Actuated Clutches . . . Bulletin No. 139-A of Twin Disc Clutch Company describes models P and PH air-actuated clutches made by this company. Both models are similar in many features to their model EH; very few alterations making it possible to substitute model P or PH for model EH. Designed particularly for heavy-duty applications, e.g., for drilling rig draw-works, the clutches are available in sizes from 14 to 42 in and capacities from 75 to 1325 hp. Sizes 30, 36 and 42 in, designated model PH, are expressly designed for applications where high torque is required.

39. Pneumatic Vibrators . . . Catalogue No. 104, issued by Cleveland Vibrator Company, gives full technical data on the complete line of air vibrators they manufacture. General purpose matchplate, springless, horizontal and vertical machine types with mounting bases and special purpose vibrators, e.g., shakeout, anneal pot rapper and wedge type male bracket are shown. Their automatic lubricators, hose fittings and operating valves are also shown.

40. Hose Couplings . . . Hose Accessories Co. describe their line of high and low pressure couplings in Catalog No. 644. Couplings, clamps, nipples and menders in malleable iron, steel, brass and bronze are shown in this 44-page catalog. Low pressure air hose couplings are offered in ½ to 1 in sizes and high pressure couplings in ½ to 3 in sizes. Illustrations showing each type of fitting and a section on proper selection and application of fittings are included.

41. Sealing and Lubricating Compounds . . . Compounds for general purpose and specialized use are described in Catalog No. 909, just issued by The Parker Appliance Company. Properties of valve lubricant, thread sealing, line sealing, gasket and anti-seize compounds for many types of tubing and piping systems are described.

HYDRAULIC POWER AT THE ROAD SHOW

Although it wasn't in the headlines, the 1948 Road Show held in Chicago in July was the largest showing of hydraulic equipment in the history of the industry. Estimates were made that between 80 and 90 percent of all power movements on equipment shown were hydraulically actuated. A total of over 300 exhibitors filled over 30 acres with the greatest number of earth handling machines ever shown in one place.

Two general trends were noted: One, the increasing size of the graders, bull dozers, cranes, hoists and snow plows; the other, the increase in the number of hydraulic unit attachments available for use with tractors and heavy standard highway trucks. A number of hydraulic engineers who attended gave credit to hydraulic power for the development of many of the larger machines, stating that equivalent mechanical power actuation would be impractical both in bulk and in the physical ability of the average operator to handle. The hydraulic attachment trend included scrapers, shovels, bull dozers, plows and lifts for use with crawler tractors, prime movers and standard highway trucks. Some of the leading manufacturers of road building and earth moving equipment introduced attachments of their own design. A representative number of pumps, valves, couplings, hose and fittings, industrial motors and electrical control systems were shown.

BOOK REVIEWS

Hydraulics

Horace W. King, Chester O. Wisler and James G. Woodburn. *Fifth Edition. 339 pages, 5½ x 8¼ inches. Published by John Wiley & Sons, Inc. at $4.00.*

The fifth edition of this standard beginning text on water hydraulics has been expanded to include new developments in theory and practice and new problems illustrating applications of basic theory to specific engineering problems not previously covered in earlier editions. New material is introduced on the variation of hydrostatic pressure with altitude in a compressible fluid, on the flow through gates and over dams, on the general consideration of the flow of liquids in pipes, on the analysis of flow in pipe networks and the resistance offered to motion of objects through a fluid.

The material is well arranged and a good index makes it easy to use for an engineer who wants to run down a definite problem. It is a useful book for the oil hydraulic engineer who runs into an occasional water hydraulic application problem and for the individual student who wishes to grasp or review basic principles of fluids at rest or in motion.

Electronics

Prepared by the Technical Staff, Coyne Electric School, Inc. 468 pages, 5¾ x 8¾ inches. Published by Coyne Electric School, Inc., Chicago, at $3.75.

The primary purpose of this book is to give a broad picture of the electronics industries as they exist today, enabling the reader to understand present methods and practices. This knowledge will enable the reader to select, install and maintain the various types of electronic apparatus described.

This book is designed for home study and field reference work. This makes it valuable to the experienced electrician or radio man as a quick, authoritative reference and to the beginner who is interested in learning how to install, repair and operate electronic equipment.

A very handy index, a large number of diagrams and illustrations and an exceptionally fine introductory chapter are included.

POST SCRIPTS OF INDUSTRY

NEWS · VIEWS · TRENDS

Mead Specialties Co., Chicago, manufacturer of air cylinders and air operated devices, has appointed R. M. Wright Co., Detroit, as its agent for most of the state of Michigan and Jackson-Walter Co., Philadelphia, as its representative for eastern Pennsylvania, southern New Jersey, Maryland and Delaware.

Economy Pumps, Inc. announces the appointment of Beldon S. Tucker as district sales manager in Chicago and Bruce Hetler as distributor for western Michigan with headquarters in Grand Rapids.

The Square D Company has recently appointed S. T. Walz as southeastern regional manager with headquarters in Atlanta, K. R. Morris as eastern regional manager with headquarters in Baltimore and R. W. Thompson as midwestern regional manager with headquarters in St. Louis.

The construction of a 60,000 ton hydraulic press for the manufacture of aircraft parts is being considered by the Air Materiel Command and manufacturers throughout the country. This press would be the largest in the world, doubling the 30,000 ton press built by the Germans before the war.[1]

Major General Kenneth B. Wolfe, Chief of Industrial Mobilization Planning, AMC, says that the development of this press would require considerable research facilities including a 20,000 ton extrusion press. This giant press would be used for the manufacture of such large aircraft parts as wing spars, etc.

[1]APPLIED HYDRAULICS, May 1948, p 17.

Richard F. Trimbach is the engineer in charge and Dr. Hubert Altwicher, German scientist who developed the 30,000 ton press at Duesseldorf, Germany is his assistant.

George D. Roper Corporation pump division has appointed Robert L. Moog as eastern division manager. From offices in New York City he will supervise sales in New York, Connecticut and New Jersey.

Automatic Transportation Co., Chicago, has received an order from Oldsmobile Division, General Motors Corp., for an industrial truck with a capacity of 80,000 pounds. This is believed to be the largest industrial truck of its type. Oldsmobile will use it for handling dies. Automatic Transportation Co. was a pioneer in the use of high pressure hydraulic systems in industrial trucks.

Appointment of The National Mill Supply Co., Fort Wayne, Indiana as a dealer for Davey Compressor Co., Kent, Ohio, has recently been announced.

Youngstown Sheet & Tube Co. has moved its Columbus, Ohio office to LeVeque-Lincoln Tower. Sam Cole is manager of the district office.

The Allen-Bradley Co., Milwaukee, announces the appointment of Robert L. Hanson as manager of their Pittsburgh office.

Link-Belt Co., Chicago, announces the appointment of Crozier S. Wileman as district manager at Wilkes-Barre, Pa. Wileman, who has been with the company since 1924, will be assisted by Alton H. Ziegler.

Hannifin Corporation, Chicago, Ill., announces the appointment of the Jack J. Kolberg Co., of Seattle, Wash., as sales agents for the Hannifin line of hydraulic and pneumatic power and production equipment in the states of Washington, Oregon and Idaho.

Merz Engineering Co., Indianapolis, has acquired exclusive patent, manufacturing and sales rights to the line of electronic inspection equipment of Jack & Heintz Precision Industries.

The National Metal Exposition will be held in Commercial Museum and Convention Halls, Philadelphia, October 25-29. The sponsors, American Society for Metals, will hold their annual convention at the Benjamin Franklin Hotel during the same week.

PERSONALS

DOUGLAS B. WHITNEY has been appointed general manager of the Harrison Radiator Div., General Motors Corp. He succeeds the late Frank J. Hardiman.

M. L. BOYLE, sales manager has been transferred to the Philadelphia office of the Hydraulic Press Division, A. B. Farquhar Co., York, Pa. He has served as chief engineer and sales manager of this division.

FRED T. MILLER has been appointed sales manager of Adel Precision Products Corp., Burbank, Calif., according to an announcement by William DeRidder, president of the com-

(Continued on page 39)

New PRODUCTS

For additional information on any of these products, mark the end key numbers on the card bound in this issue and mail the card.

Hydraulic Power Unit

A compact hydraulic power unit formerly used with lift trucks and sheet feeding tables is now being offered as a separate piece of equipment by its manufacturer Lyon - Raymond Corporation. The unit consists of a 1½ gpm pump developing 1000 psi, a three- or four-way control valve of the open center type, adjustable relief valve, a 2½ gallon oil reservoir and a ¾ hp ac motor. This unit is compact and can be used for any number of industrial applications. Use Business Reply Card, mark NP-1.

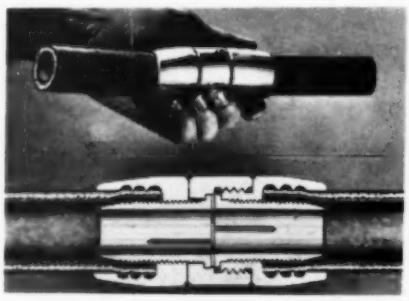
Pressure Switch

A new low pressure switch with 20 amperes inductive sensitivity and differential adjustment has been developed by DiaPHlex, a division of Cook Electric Company. Named the "Hy-G", this switch is very compact and is available with pres-

sure and electrical connections in optional positions. Wide temperature stability range, protection against high pressure surges and adjustable pressure range to 30 psi are features of this switch design. Use Business Reply Card, mark NP-2.

High Pressure Coupling

A new streamline high pressure hose coupling is manufactured by the Bar-Way Mfg. Co. Produced in ½, ¾ and 1 in sizes, this coupling will withstand pressures of more than 3000 psi. The full inside diameter of the hose is maintained throughout this coupling, permitting



unrestricted flow. Expander screws are used to squeeze the hose and prevent twisting and turning and a swivel nut is incorporated to facilitate easy removal of the unit by using a squared wrench. Use Business Reply Card, mark NP-3.

Speed Control Valve

A new speed control valve for air or hydraulic cylinders is available from Galland-Henning Company. This valve, capable of controlling flow in one direction, is designed for maximum pressures to 300 psi. It is easy to adjust, has a large capacity because of the incorporation of a wide diameter sleeve instead of the conventional needle valve and is easy to install. Only one size is available but it can be tapped out to ¼, ⅜ and ½ in pipe sizes as desired. Use Business Reply Card, mark NP-4.

Magnetic Starter

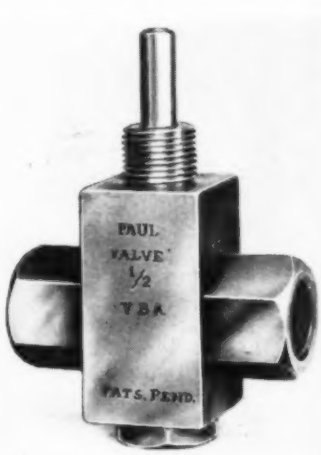
Ward Leonard Electric Co., announces the development of their new size 1 ac magnetic starters for non-reversing, across-the-line starting of polyphase squirrel cage induction motors and single phase motors. The new starters are available with open type construction or NEMA Type 1 General Purpose Enclosures. They are suitable for use with separate pilot devices for 2 or 3 wire remote control; they can be supplied with local control pushbutton stations or selector switches. Bulletin 4111 gives full specifications. Use Business Reply Card, mark NP-5.

Small Pressure Switch

A new line of small size pressure switches for use with small compressors, oil pumps or any motor driven pump on a pressure system is announced by Cutler-Hammer, Inc. Two types are available—one with external range adjustment and the other without. Both types are mounted within a stainless steel frame. This design features silver-to-silver contacts and a positive quick-make and quick-break action. Maximum pressure to open is 80 psi and minimum pressure to close is 5 psi. Use Business Reply Card, mark NP-6.

Automatic Valve

A new lightly operated valve for low pressure operation is offered by Paul Valve Corporation. It is a straight-through valve that gives quick action and trouble-free operation. The body of this new valve is shaped inside like a venturi tube and incorporates only two moving parts. It can be actuated by cam,



lever, solenoid or diaphragm. Use Business Reply Card, mark NP-7.

"Push Button Efficiency..."

Saves Time and Labor on Snowplows, Dump Trucks and other 6-v, d.c. jobs

Things happen fast when you push the right button! On snowplows and dump trucks the right button actuates Pesco's new *electric motor-driven power package.* Just by pushing a button, conveniently located on the truck's instrument panel, the operator has full control of raising the snowplow blade . . . or dump truck body. A control lever lowers blade or dump body just as quickly. It's fingertip control that makes possible quicker, more accurate operation . . . saves time and labor. In the case of snowplow operation it makes possible better control of the snowplow blade in following road contour, passing obstructions, etc.

This new Pesco electric motor-driven power package consists of a 6-v, d.c. electric motor, hydraulic pump, reservoir, check valve and relief valve . . . all built into one compact, streamlined unit. It has a capacity of .7 g.p.m. at 1000 p.s.i. at 6 volts, at which time it has a current requirement of 150 amperes. The reservoir can be provided in various sizes depending on the requirements of the job, or the unit can be furnished without the reservoir in cases where a separate, extra large reservoir is required. The hydraulic pump features Pressure Loading, Pesco's exclusive development which makes possible high operating efficiencies at all times.

Whether you design and manufacture snowplows or dump trucks, farm machinery or road machinery, hydraulic presses or machine tools, Pesco manufactures power packages, hydraulic pumps, motors, control valves that make possible more efficient operation, more positive control . . . and easier sales. Write today for full information.

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MANUFACTURERS OF BW SUPERCHARGERS

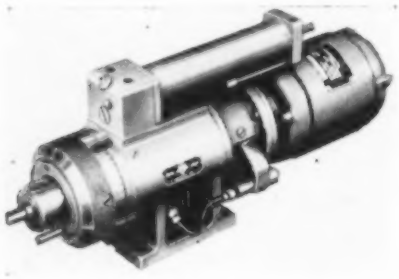
Hydraulic Power Unit

Hydraulic power control units incorporating supercharged pumps are offered by LaPlant-Choate Manufacturing Co., Inc. The units are composed of a rotary gear type pump with two interchangeable gears, three-

position control valve, spring relief valve and a 1½ to 2½ gallon reservoir. The supercharged action is obtained when the return oil from the lift side of the actuated cylinder forces oil under pressure to the pump gears. Capacities range from 15 to 60 gpm at pressures to 1000 psi. Use Business Reply Card, mark NP-8.

Air-Hydraulic Drillhead

An air-hydraulic drillhead incorporating hydraulic feed and air controlled approach and return is manufactured by Cleveland Republic Tool Corporation. The unit containing a motor, spindle and operating mechanism is totally enclosed to prevent the entry of dirt, chips and coolant. The air pressure required



ranges from 50 psi minimum to 100 psi maximum and feed rates possible range from 0 to 75 ipm with a maximum stroke of 1¼ in. Use Business Reply Card, mark NP-9.

Solenoids

A new type of solenoid incorporating only five component parts is announced by Practical Electric Company. New "T" shaped armature, fan-proof laminations, quiet operation and high efficiency are features of this design. Strokes range from ⅛ to ⅝ in. Use Business Reply Card, mark NP-10.

Air Valve

A four-way by-pass air valve for use with double acting air cylinders is available from Knox Industries, Inc. This valve is of the revolving disc type, self sealing, lapped, all metal construction, that eliminates the use of packings. A feature of this valve is the use of half of the compressed air, normally required for the power stroke on double acting cylinders, to return the piston to its starting position.

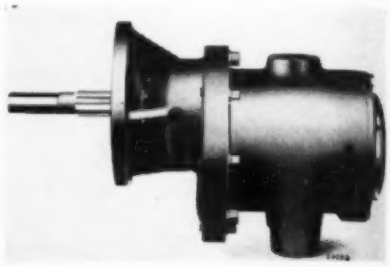
It is built for pressures to 150 psi and is available in ¼, ⅜ and ½ in sizes. Use Business Reply Card, mark NP-11.

Torque Control System

Eclipse-Pioneer Division, Bendix Aviation Corporation has announced the development of a remote control torque system, that is adaptable to many industrial applications. Already used successfully in automatic pilots and engine control systems, it provides an electrical means for either manually or automatically transforming a very weak motivating force into control of a predetermined operation at a remote location. The system consists of a transmitter, a torque unit and an amplifier; torques range from a few gram-centimeters to several foot-pounds. Bulletin 711-21 describes this system. Use Business Reply Card, mark NP-12.

Air Motors

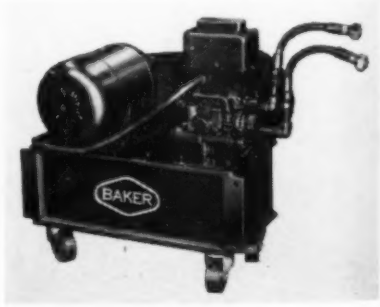
Air motors for use as internal combustion engine starters or other similar duties are now produced by Ingersoll-Rand Company. They are small and



compact and are available in two sizes—9 and 20 hp—for use on 90 psi air lines. The motors are of the multi-vane type and incorporate a throttle valve of the quick opening type. Single step spur gearing is used for obtaining suitable speeds. Use Business Reply Card, mark NP-13.

Portable Power Unit

Baker Brothers, Inc. offer a mobile hydraulic power unit mounted on casters. This new unit greatly reduces downtime because units are interchangeable in case of a break down. The unit consists of a variable delivery radial piston pump, built-in solenoid actuated control valves, a 12 gallon oil sump and a 2 hp motor. This unit can be applied to any hydraulically fed



machine requiring rapid traverse, feed and neutral; rapid traverse pressure is 300 psi and feed pressure is 1000 psi. Use Business Reply Card, mark NP-14.

PERSONALS

(Continued from page 35)

pany. Miller has been with the firm for seven years and has been west coast representative for his company.

NORMAN R. IRVINE has been appointed by the Pressed Steel Tank Co., Milwaukee, to represent the company in several southern states.

CHARLES E. CLEMINSHAW has been named chief industrial engineer for The Parker Appliance Company according to an announcement by Robert W. Cornell, vice president in charge of manufacturing. From 1933 to 1941 he was an industrial engineer for Republic Steel Corporation, during the war he was associated with the War Production Board and the War Department.

Mr. Cleminshaw

ELLISON L. WERFEL has been named chief engineer for Lombard Corp., Youngstown, Ohio. Werfel was associated with Oilgear Co. from 1937 till recently as special hydraulic engineer. Edgar P. Hulse was appointed assistant chief engineer.

FRANK HARRISON, former vice president of Curtiss-Wright Corp., has been named assistant to LaMotte Cohu, president. He will assist in production management at the San Diego division.

GEORGE W. SMITH has been elected president of De Laval Steam Turbine Co., Trenton, N. J. He succeeds H. L. Watson who has retired after 35 years of service. Watson will continue in the capacity of director and chairman of the executive committee. Smith has served in executive positions with White Motor Co., Bendix Aviation Corp., Ohio Crankshaft, Inc. and as chief engineer for the Naval Aircraft plant, Philadelphia.

MECHANICAL ENGINEER

Position with manufacturer of road machinery and material handling equipment. Experience in designing hydraulic mechanisms is essential. Location is within 40 mile radius of Chicago. Please give complete details to Dept. 9148, APPLIED HYDRAULICS.

HAROLD T. ANDERSON has been named assistant to the general sales manager in charge of sales production relations for Worthington Pump and Machinery Corp., Harrison, N. J. He has been associated with this company since 1924.

THOMAS R. TURNER has been appointed a divisional sales representative by Watson-Stillman Co., Roselle, N. J. His territory will include Virginia, Maryland, Delaware, southern New Jersey and eastern Pennsylvania.

HOWARD STEVENS has joined Saval, Inc., Los Angeles, as head of industrial sales promotion. This corporation manufactures a line of high and low pressure directional control valves for air and oil service. For the past eleven years Stevens has been associated with Watson-Stillman Co., Roselle, N. J., covering their northeastern section for their special hydraulics division.

Mr. Stevens

W. D. REED has been elected president of Star Tubular Products Co., Chicago and Richard L. Kopp secretary. They were both formerly associated with Sawhill Mfg. Co.

THOMAS NAST has been elected president and treasurer of Kenisco Tube Co., Mt. Kisco, N. Y. He was formerly with Revere Copper & Brass, Inc. and also served chief of production section, brass mill branch, War Production Board.

RALPH S. POULSEN has been appointed Ohio district sales manager by Lindberg Engineering Co. of Chicago.

H. R. CRITTENDEN will succeed Roy G. Messner as Chicago Division manager for George D. Roper Corporation of Rockford, Illinois. Mr. Crittenden has been with Roper for thirteen years, the last eleven in the Chicago office.

WALTER L. FLINN has been named application and sales engineer for Vickers Inc. He will succeed Phillip H. Emrich, recently appointed service manager for all Vickers hydraulic products.

LLOYD L. LEE has joined the staff of Cleveland Republic Tool Corporation as manager of their Detroit office. Mr. Lee has been associated with Wolverine Machinery Co. and the Wilcox-Rich Division of Eaton Corporation.

W. D. GILDER has been named project engineer at the Weatherhead Co., Cleveland. Gilder came to Weatherhead from the National Tube Co.

WILLIAM J. THOMAS has been appointed general sales manager, Babcock & Wilcox Tube Co., subsidiary of Babcock & Wilcox Co. of New York. Since 1942 he has been assistant sales manager.

WALTER GEORGE WHEELER has been appointed chief engineer of Hufford Machine Works, Redonda Beach, California manufacturers of special hydraulic equipment. He is a graduate of California Institute of Technology and a member of A.S.M.E. and joined forces with Hufford in 1947. His new duties will include the improvement and development of hydraulic equipment.

Mr. Wheeler

JOHN G. SEILER has been appointed executive vice president of Tube Turns Inc., Louisville. He became associated with this company in 1930 and was appointed sales manager in 1931 and general sales manager in 1945.

DON G. SAVAGE has been elected vice president in charge of sales for The Thew Shovel Co., Lorain, Ohio. He has been general sales manager of the company since 1935.

GILFREY WARD has been appointed vice president of the Kellogg Div., American Brake Shoe Co. He has been associated with this company since 1928.

JOHN O. GLENN, formerly assistant manager of the merchandising division, has recently been appointed manager of pump and compressor sales for Worthington Pump and Machinery Corp., Harrison, N. J.

THOMAS F. MARLOW has been elevated to vice president in charge of operations at Standard Tube Co., Detroit. He had been works manager since 1944.

RENKE BRUNKEN has been named president of Torcon Corporation, Chagrin Falls, Ohio. Brunken until recently was transmission engineer at the White Motor Company.

J. C. CARR has joined the Burndy Engineering Co., Inc., New York, as sales promotion manager. He was formerly connected with Kollsman Instrument Div., Square D Co.

GEORGE J. FISCHER has been promoted to manager of national accounts, Industrial Products Sales Division, B. F. Goodrich Co., Akron.

R. I. PARKER has been elected commercial vice president of General Electric Co., Schenectady. He succeeds W. O. Batchelder who is retiring after 40 year's service.

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